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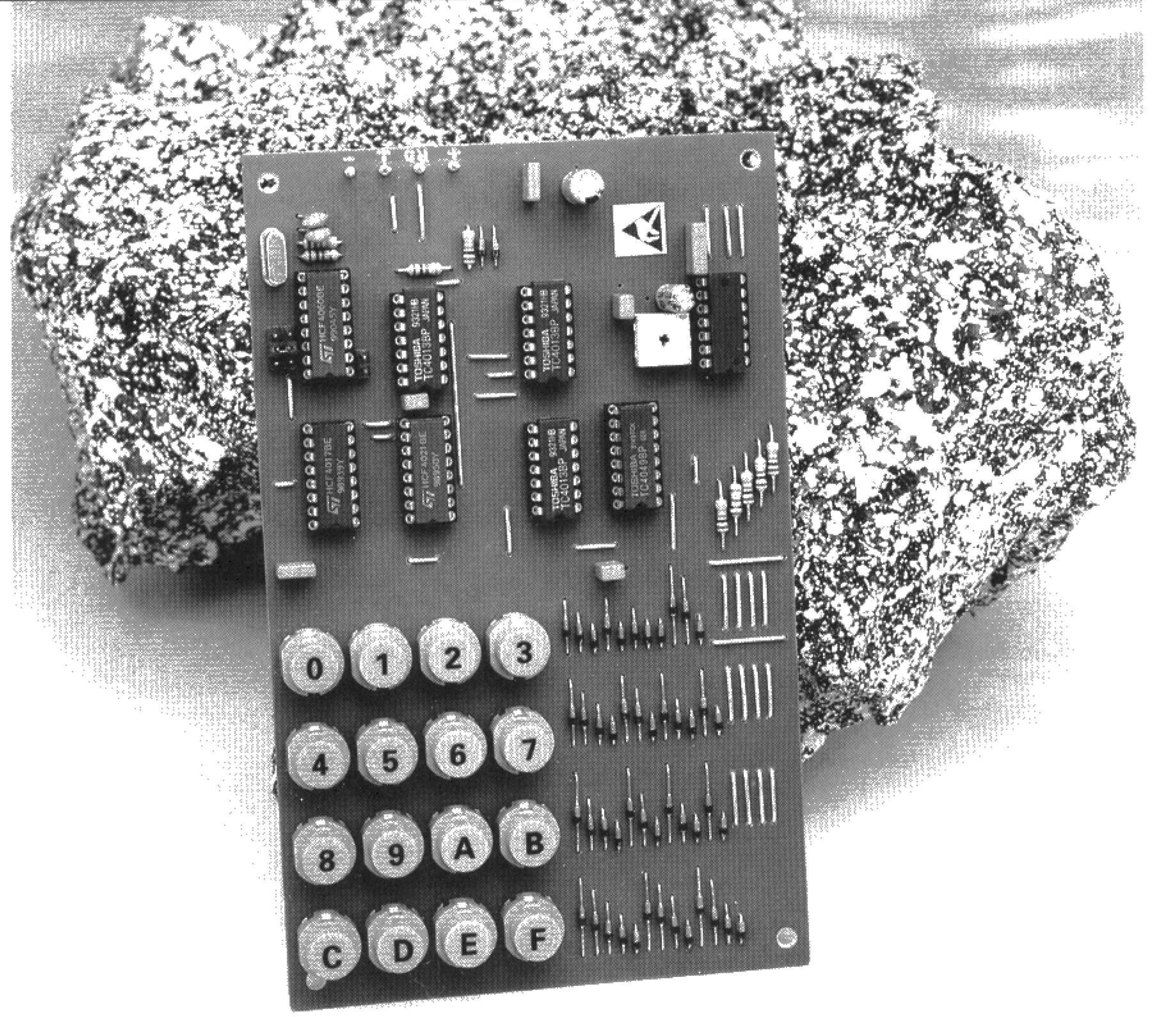
See page 6

hexadecimal keyboard for PCs

uses the serial port and a small program



For some programming applications such as writing Pascal units, you have to enter lots of hexadecimal numbers. Using a standard PC keyboard for this type of work is cumbersome as the relevant number and letter keys (0-9 and A-F) are not grouped together. To make hex number entry a lot easier, the author designed an add-on hexadecimal keyboard which is connected to the PC's serial port. The hardware is controlled by a simple program of which the full listing is given in this article.

Design by D. Pflüger

All you have to do to be able to use the present keyboard is connect it to the RS232 port of your PC, and load a small driver program (HEXKEY.EXE). Because the Pascal source code of this program is printed in this article, programmers may make any modification they feel necessary, and then compile a new executable program.

The circuit

One of the aims in designing this circuit was to stick to commonly available components only, enabling anyone to build the keyboard without placing large orders on mail-order retailers or visiting the local electronics shop.

The keys S1 through S16 shown in the keyboard schematic, **Figure 1**, are connected to diodes D1 through D48 in a manner that enables the key code to be output in 4-bit binary form on lines A1-A4. The TCLK line is automatically activated whenever a key is pressed. Because the signals first appear in negative logic, they are inverted and buffered by IC8. The hex code 'F_H', for example, is originally available on the switches as value 0000, and '0_H', as 1111.

The circuit diagram of the binary to serial converter is given separately in **Figure 2**. The keyboard output signals A1-A4 are applied to the bistables in IC2 and IC3, which latch them when the TCLK signal, delayed by IC1-R1-C1, goes high briefly at the CLK inputs. At the same time, TCLK causes the bistable in IC4 to be cleared, and the clock signal for decimal counter

1

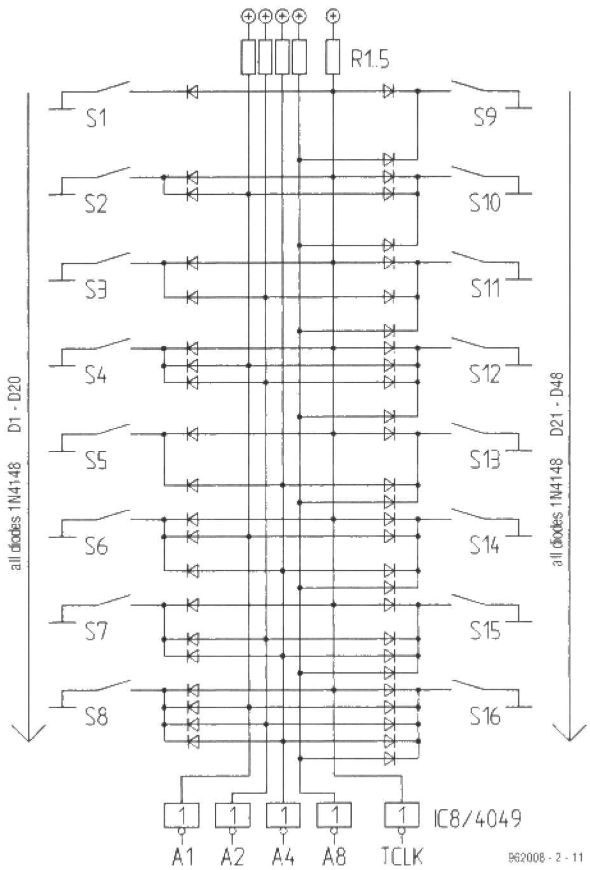
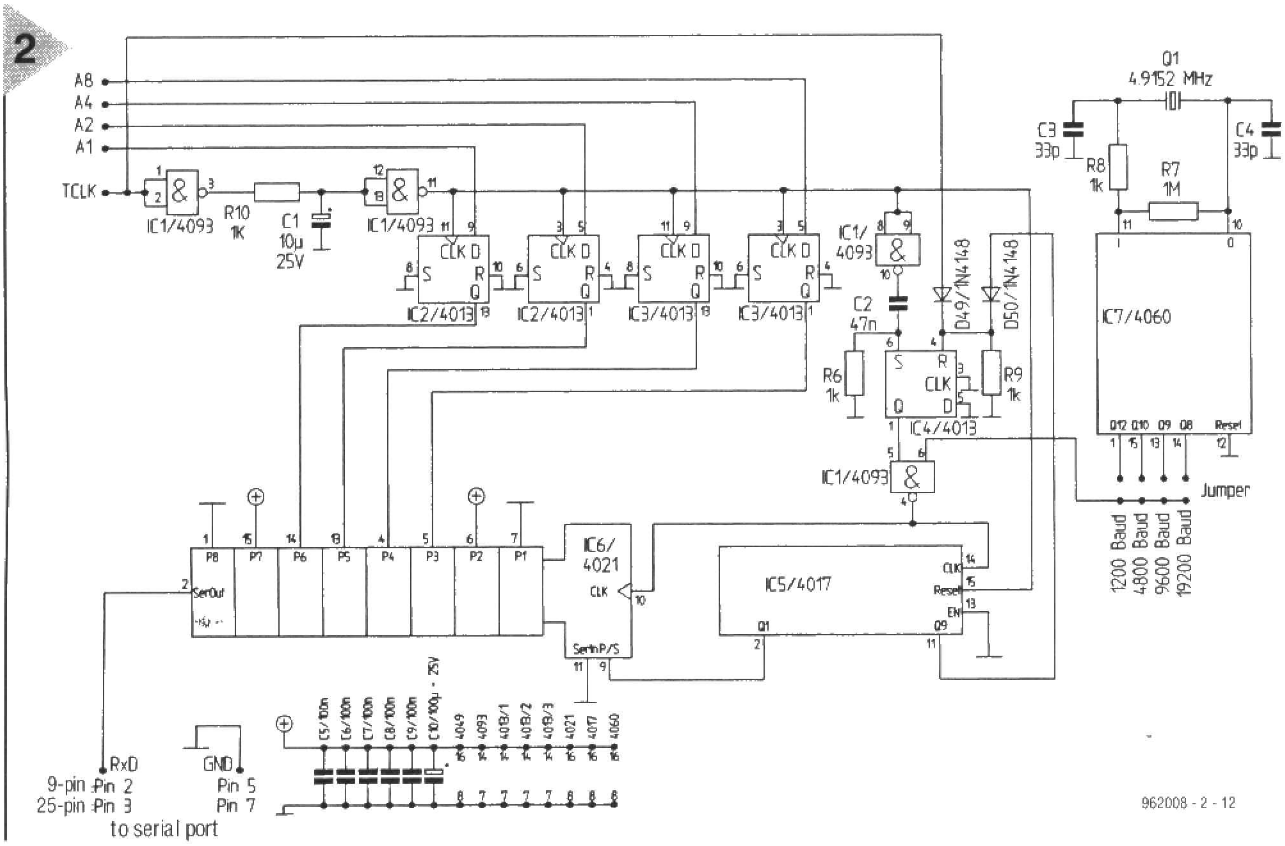


Figure 1. Circuit diagram of the hexadecimal keypad.

Figure 2. Circuit diagram of the binary-to-serial converter.

2



IC5 and shift register IC6 to be enabled. The shift register has copied the hexadecimal number via its six inputs, output Q1 of IC5 is logic high, and the hex number appears in serial form at the SerOut output. Meanwhile IC5 keeps track of every shift operation. When the value '9' is reached, output Q9 goes high, resetting bistable IC4 again and disabling the shift register clock until the next key is pressed.

Inputs P1, P2, P7 and P8 of the shift register are tied to ground or the positive supply voltage to enable the necessary start and stop its to be generated. The circuit works with five databits, one stop bit and no parity bit.

The clock generator consists of a CMOS 4060 whose divider outputs supply the clock rates 1200, 4800, 9600 and 19200 Hz. Although the driver program as shown here is designed to operate at the 19.2 kbit/s rate, it is easily modified if you require a different port speed.

CONSTRUCTION

The circuit will not be too difficult to build on a small piece of stripboard or veroboard. If necessary, the keypad and associated components may be built on a separate board.

The switches are either 'D6' types or the more expensive (but more reliable) Digitast keys from ITT/Schadow.

The last action is to solder the ICs on to the board, or insert them into their sockets. The prototype shown in the introductory photograph was built using IC sockets with turned pins.

The circuit is either powered by a mains adaptor (8-12 VDC), or the supply voltage is 'stolen' from the PC, which will have a 12-V line available somewhere in the internal supply wiring.

The basic connection details on the

Figure 3. Pascal listing of the Hexkey program. Copy and compile!

3

```
{ *********************************************************************** }
{ * Program Name: HEXKEY                                                * }
{ * Version: 1.0                                                        * }
{ * Program language: Turbo Pascal from 6.0                             * }
{ * Author: Dietmar Pfluger                                             * }
{ * Function: scans and reads a hexadecimal add-on keypad using a       * }
{ *              serial port.                                           * }
{ *********************************************************************** }

PROGRAM HEXKEY;
{$M 1024,0,0}
{$R-,S-,I-,F-,A-,V+,B-,D-,L-}
USES DOS;
CONST IntNumber=$1C;                           { timer interrupt, i.e. the     }
                                               { hex keypad is interrogated    }
                                               { 18.2 times per second         }

      Chars: Array[0..15] of Char              { characters to be produced     }
        = ('0','1','2','3','4','5','6','7','8','9','A','B','C','D','E','F');

VAR   OriginalInterrupt:Pointer;
      ComAdr:Word;

FUNCTION SERIAL_ADDR(COM_Nr:Byte):Word;        { Determine serial address      }
  BEGIN
    SERIAL_ADDR:=MEM[$0040:$0000+((COM_Nr-1)*2)]+
                 MEM[$0040:$0000+((COM_Nr-1)*2)+1]*256;
  END;

PROCEDURE INITCOM;
  VAR ComPort:Byte;
      Dummy:Byte;
      Parameter:String[1];
      Error:Integer;
  BEGIN
    If ParamCount=0 then
      Begin
        Writeln('Call: HEXKEY <COM #>.');
        Halt(1);
      End;
    Parameter:=ParamStr(1);
    Val(Parameter,ComPort,Error);
    If (ComPort=0) or (Error<>0)
      then
        Begin
          Writeln('Interface not available!');
          Halt(2);
        End
      else
        Begin
          ComAdr:=Serial_Addr(ComPort);
          Writeln('HexKey installed on COM ',ComPort);
        End;

    Port[ComAdr+3]:=128;                       { Actuate serial port module    }
                                               { for baud rate setting         }
```

serial link between the keyboard and serial port on the PC are shown in the second circuit diagram, near the shift register output. The link consists of two wires only, handshaking is not used.

The program

The Turbo Pascal source file you will need to be able to compile HEXKEY.EXE is shown in **Figure 3**. Type this listing into an ASCII word processor, and save it as HEXKEY.PAS.

No attempt has been made to produce a perfect program. No doubt the use of assembler code would have resulted in a better, more compact and faster program, but my skills in this particular area being what they are, a Pascal program was the best I could produce!

The program as it stands does not check for previous installations. I also attempted to actuate the driver via the serial port interrupt, alas, without success.

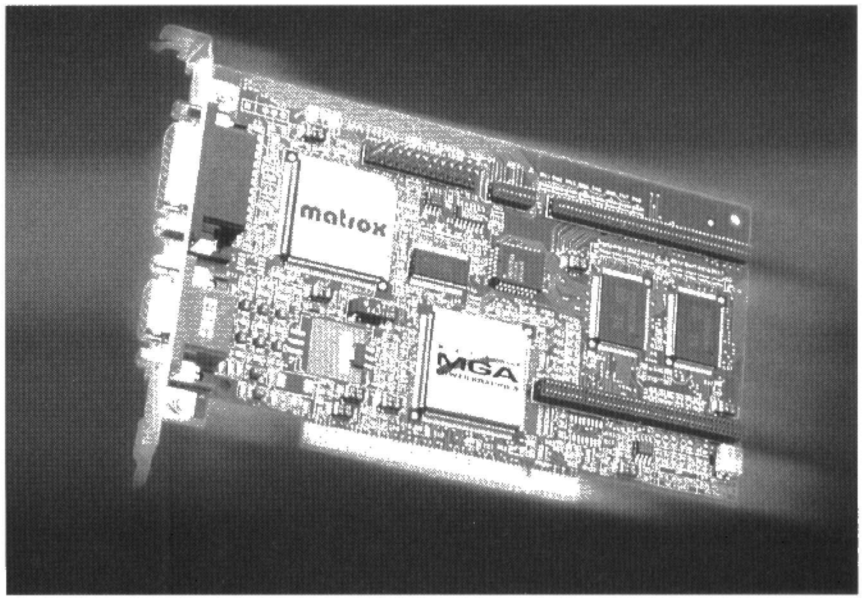
(962008-2)

```
    Port[ComAdr]:=06;                         { Baudrate LowByte, 19200 Baud }
    Port[ComAdr+1]:=00;                       { Baudrate HighByte            }
                                              { Baudrate   LowByte  HighByte }
                                              {    1200       96          00 }
                                              {    2400       48          00 }
                                              {    4800       24          00 }
                                              {    9600       12          00 }
                                              {   19200       06          00 }
    Port[ComAdr+3]:=0;                        { 5 data bits, no parity       }
                                              { 1 stop bit                   }
    Dummy:=Port[ComAdr];                      { Clear receiver registers     }
  END;

{$F+}
PROCEDURE HKInterrupt; INTERRUPT;
  VAR Key:Byte;
      Z,S:Byte;
  BEGIN
    If Port[ComAdr+5] and $01 = 1             { Check if character received }
      then
        Begin
          Key:=(not Port[ComAdr])-240;        { Request character            }
          Z:=Ord(Chars[Key]);                 { Assign ASCII code            }
          S:=00;                              { Assign scan code             }
          ASM                                 { Write character into         }
                                              { keyb. buffer, interrupt $16  }
                                              { sub-function 5               }
            MOV AH,5;                         { Load sub-function in         }
                                              { AH register                  }
            MOV CH,S;                         { Scan code in CH register     }
            MOV CL,Z;                         { ASCII code in CL register    }
            INT $16;                          { Call interrupt $16           }
          End;
        End;
  END;
{$F-}

PROCEDURE INSTALLINTERRUPT;
  BEGIN
    GetIntVec(IntNumber,OriginalInterrupt);   { Save old interrupt           }
    SetIntVec(IntNumber,@HKInterrupt);        { Divert interrupt to its      }
                                              { own function                 }
  END;

{*************************************************************************}
{*                    M a i n   P r o g r a m                            *}
{*************************************************************************}
BEGIN
  InitCom;                                    { Initialise interface         }
  InstallInterrupt;                           { Install interrupt procedure  }
  Keep(0);                                    { Quit program, stay resident  }
END.
```

graphics cards for PCs

The two elementary interfaces between man and computer are the keyboard and the mouse for manual data entry, and the monitor which basically returns the computer's response to our input actions. For an analogue peripheral device like the monitor to visualize computer data, an adapter is required which converts the digital computer signals into a form that is comprehensible by the display. This, basically, sums up the function of a graphics, or video, card fitted in a PC. Because video card manufacturers release faster and better VGA cards all the time, keeping track of market developments has become difficult if you want to make an informed choice.

By H. Koerfer-Bernstein



A LITTLE HISTORY

The first graphics cards to be widely used in combination with XT-PCs were the Hercules (HGC) and MDA cards (MDA = monochrome display adapter). The Hercules company, which is still active in this field, gave their name to this standard. The original HGC and MDA graphics cards supported monochrome (black-and-white) mode only. Odd as it may seem, this was not necessarily a disadvantage. Graphics software and hardware being hard to get and very costly in those early computer days, the main application of a PC was word processing, for which the simple black-and-white displays were perfect.

The introduction of the CGA (colour graphics adapter) and the EGA (enhanced graphics adapter) marked the arrival of colour on the PC screen. In spite of its limited (now incredibly low) resolution of 320×200 or 640×200 screen pixels, the CGA standard was exploited for the first graphic applications and computer games.

Resolution refers to the number of picture elements (pixels) that make up a complete image as it appears on the display. The number of horizontal pixels is usually mentioned first. So, in the case of the above example, 640×200 means 640 horizontal pixels by 200 vertical pixels, or a total of 128,000 pixels. As with today's generation of VGA cards, the data fed to the monitor was analogue. Some older PCs you may come across are still capable of emulating this mode. Because of the limited image quality offered by the CGA, a new graphics adapter, the EGA, was rapidly accepted, offering up to 64 colours and a screen resolution of 640×320 pixels (later versions of this card achieved 800×600 and even 1024×480 pixels). The EGA standard ruled that the data be transferred digitally to the monitor, using TTL signals.

The graphics cards mentioned so far were widely used in PCs until IBM introduced the VGA card (video graphics array) for use in their PS/2 series of computers. This system caused a small landslide as far as video cards were concerned. The first members of this new adapter generation offered a resolution of 640×480 pixels, and were capable of displaying 262,144 different colours. Today, it is fair to say that the VGA system has become the *de-facto* standard, and it is likely to remain so for some time to come. Nowadays, improved versions of the original VGA card achieve screen resolutions of up to 1,600×1,200 pixels at 16.7 million colours, provided, of course, you have the appropriate monitor.

VGA cards, however, did cause

some problems as PC (motherboard) and CPU technology developed at an even faster pace. A special video driver is invariably required for graphics cards to function at all, mainly because they offer different resolutions, yet have to run under all operating systems. Moreover, their manufacturers will typically apply different chip sets. The difficulty in selecting the right video driver, or being able to obtain one at all from the manufacturer, are often unexpected sources of frustration with many a proud owner of a new video card.

The technology

The block diagram in **Figure 1** shows the basic structure of a graphics card.

At the heart of the system is a digital-to-analogue converter, which in computer lingo is called the DAC or RAMDAC. Its function is to convert the (digital) computer data into red (R), green (G) and blue (B) components which enable the monitor to display a sharp and stable colour image. The DAC thus forms the PC-to-monitor interface proper.

The second main component on a graphics card is the video memory. Its first function is to act as an intermediate storage device for the signals received from the bus. The size of this memory also determines the maximum achievable resolution and colour depth that can be displayed on the monitor (provided, again, the monitor is capable of handling the picture format and resolution).

A simple example may be useful to illustrate the above condition. An image with a resolution of 800×600 pixels and a colour depth of 16 bits ('high colour' mode, 65,536 colours) requires exactly 7,680,000 bits to be stored. Converting this to bytes results in 960,000 bytes. Consequently, this resolution is only possible if the video card has a memory of 1 Mbyte. A 'true colour' (16.7 million colours) image at this resolution then already requires a video memory capacity of 2 Mbytes (although strictly speaking 1.5 Mbytes would be sufficient). The exact relation between the number of displayable colours and the required number bits per pixels is shown in **Table 1**.

Historically, 'more' RAM on a graphics card has always meant doubling the size: the first VGA adapters were equipped with 256 kB. Then came cards with 500 kB, 1 MB, 2 MB, 4 MB and, finally, even 8 MB of video RAM. Cards with 256 kB and 500 kB now seem to have vanished from the market, not including rallies and car boot sales, of course. The entry level these days seems to be 1 MB of RAM, although it will be wiser in many cases to go for 2 MB. 4 MB or 8 MB of RAM should only be necessary for the professional CAD or DTP user having a 21-inch monitor.

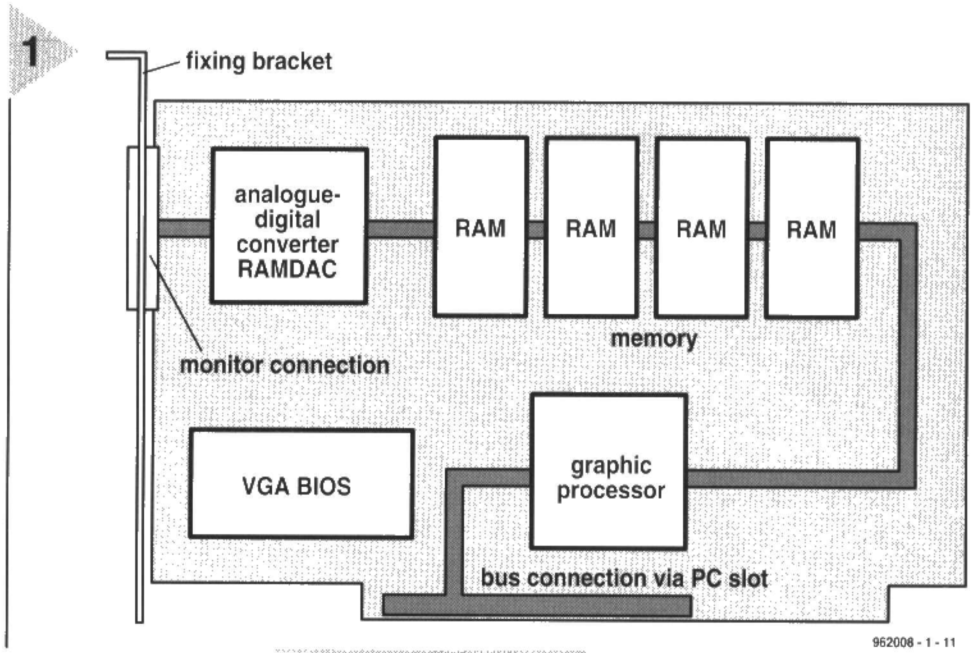


Figure 1. Main functional blocks in a VGA card: DAC, memory and, on newer cards, the graphics processor (or accelerator).

Another important element on the video card is the video processor. In the old days, this chip used to be available on powerful and expensive graphics cards only. Today, no VGA card is sold if it does not have such an 'accelerator', while the prices have also dropped considerably. True, surplus video cards without a dedicated graphics processor are still sold here and there, but I would not advise buying one of these because any savings you seem to make are paid back later as you sit in front of the monitor waiting for the picture to be built up. These accelerator modules considerably lighten the CPU load formed by display functions, leaving more time to the CPU to handle other jobs. As a result, a graphics accelerator can help to boost the overall PC performance considerably.

There is another hardware-related measure which will also produce a performance boost: the use of a wider data bus on the graphics card. Although the PCI interface between the CPU and the graphics card has a width of 32 bits, this bus is internally widened to 64 or even 126 bits. This results in a tremendous increase in data throughput between individual components on the card (graphics accelerator, memory and RAMDAC). While older cards used to have an internal 32-bit bus, this was widened to 64 bits and even 128 bits by some manufacturers. Although 32-bit cards are still sold, 64-bit versions are now considered the standard. Three manufacturers, Number Nine, Hercules and VideoLogic produce 128-bit video cards, and others will no doubt follow suit.

However, as we will see, widening the data path is not the only factor contributing to the increased speed of today's video cards. Other factors, like the latest DAC developments (using ever higher sampling frequencies) and the use of new chip technologies for the video memory have a tremendous effect on the performance of video cards.

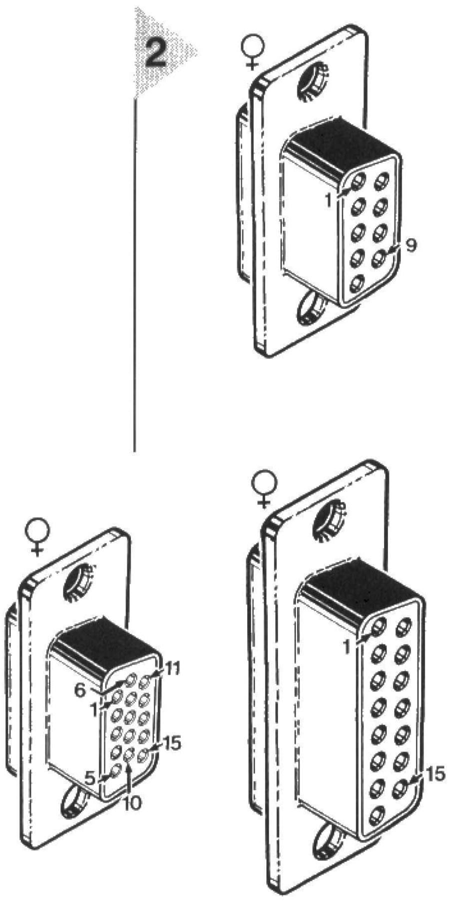
The RAMDAC

This unit, which fetches picture information from the video memory and prepares it for use by the monitor, ranks very high in the video building block hierarchy. It's easy to see why: new data may not be written into the RAM before the RAMDAC has read

Table 1. The number of bits required to give one pixel a certain colour.

Black/white	2 bit	VGA monochrome (bright/dark)
16 colours	4 bit	standard VGA mode
256 colours	8 bit	super-VGA mode
65,536 colours	16 bit	High Colour mode
16,777,216 colours	24 bit	True Colour mode

2



Pin	Herc\MDA	CGA	EGA
1	GND	GND	GND
2	GND	GND	Red 2
3	NC	Red	Red 1
4	NC	Green	Green 1
5	NC	Blue	Blue 1
6	Brightness	Brightness	Green 2
7	Signal	NC	Blue 2
8	H-Sync	H-Sync	H-Sync
9	V-Sync	V-Sync	V-Sync

Pin	VGA/Colour	VGA/Monochrome
1	Red	NC
2	Green	Signal
3	Blue	NC
4	NC	NC
5	Diagnostic	Diagnostic
6	Red GND	NC
7	Green GND	Mono GND
8	Blue GND	NC
9	NC	NC
10	Sync GND	Digital GND
11	ID 0	NC
12	ID1	Digital GND
13	H-Sync	H-Sync
14	V-Sync	V-Sync
15	NC	NC

Figure 2. Pinning of the connectors on commonly used video cards.

out the current data. In this way, the speed of the entire video card, and, consequently, that of the entire PC, is dependent on the conversion speed of the RAMDAC. The *pixel rate* is the characteristic that indicates the performance of the DAC. The pixel rate is calculated as resolution times picture refresh rate, plus a third of this product. An example: you would like a resolution of 1,024×768 pixels at an ergonomically warranted screen refresh rate of 85 Hz. This results in 1024×768×85 Hz = 66,846,720 Hz. This value has to be increased by about one third to allow for the synchronization and blanking signal overhead. The result is 89.146960 MHz, say, 90 MHz. Good DACs these days achieve conversion rates of up to 220 MHz.

The memory elements

Today, there's a confusing variety in chip technologies used for video RAMs. Until recently, the only differences was that between DRAMs (dynamic random access memory, also used for the PC's main program memory) and the faster VRAMs (video random access memory). Nowadays, it seems as if every video card manufacturer comes up with a new memory technology like EDO-RAM, WRAM (Window RAM), dual-ported RAM and multi-band DRAM.

The advantage of VRAM chips over DRAMs is that they have separate pins for reading and writing picture data. Because of this, they are also called 'dual-ported' RAMs. The separate input and output channels enable simultaneous reading and writing of data. By contrast, a regular DRAM can only do one thing at a time: accepting or supplying data. The data throughput of a video card which uses VRAMs is almost twice that of a card based on conventional DRAMs or even EDO-RAMs.

The operation of WRAMs is similar to that of VRAMs, although they have to be even faster because of the higher clock frequencies. Matrox normally fits WRAMs on its video cards.

EDO RAMs, already mis-used as an alibi for true level-2 cache, have buffer stages ahead of their outputs. These buffers allow EDO RAMs to fetch the next information while they are accessed. It should be clear, however, that the data throughput achieved with these chips is only marginally higher than that offered by regular DRAMs.

A further novelty from VideoLogic and Hercules is called *multi-bank DRAM*. As far as their construction is concerned, these memory chips look very much like DRAMs. However, the modified technology to access the memory contents, coupled with synchronous access to partly overlapping 32-kByte memory blocks allows data to be moved around at very high clock rates. Until you have actually tested and gauged the performance of these cards, it remains to be seen whether multi-bank DRAM is really an alternative to VRAMs, or if the latter are still to be preferred.

Drivers

A graphics card is hardware, and totally useless without the appropriate bits to control it. The piece of software that enables the card to present those wonderful images on the monitor is called the *driver*. The function of the driver is to adapt the VGA card to different operating systems (Windows, OS/2, etc.), and to provide a working link to some special application programs. Consequently, you need a new driver every time you wish to upgrade to a new operating system. The arrival of Windows 95 once again showed how far many card manufacturers are behind when it comes to providing the appropriate drivers. There were even manufacturers who failed to have updated drivers available six months after the introduction of the new operating system. In many cases, it's a good idea to ask the manufacturer of your favourite video card where driver updates are held, and how they may be obtained (mail on request, mailbox, ftp, Internet, etc.). Alternatively, probe other users for their practical experience with driver updates.

Moving pictures

The ability of a video card to actually produce moving images (i.e., video as used with TV sets) seems to be a good sales argument. It is questionable, however, if many PC users will bother to use this feature. After all, the VCR is usually available right next to the TV set.

Video signals for use on PCs are usually supplied by the CD-ROM player. The format of the digitized picture sequences is usually Microsoft AVI (audio video interleave) or MPEG (motion picture expert group). In case you did not know, MPEG was the name of a workgroup before it became the name of a video standard using compression/decompression techniques. The aim is clear: today's home PCs (bought and used by private individuals) have meanwhile reached performance levels that bring video edit-

Table 2. Relation between monitor (screen) size, resolution and picture refresh rate.

Screen diagonal	good resolution	highest resolution	H frequency for 85 Hz refresh rate
14 inch	640 × 480	80 × 600	45 kHz
15 inch	800 × 600	1024 × 768	56 kHz
17 inch	1024 × 768	1280 × 1024	73 kHz
19 inch	1200 × 1024	1600 × 1200	96 kHz
21 inch	1600 × 1200	2000 × 1500	111 kHz

ing within reach. Companies like FAST, Digital Device Development and Optivision already supply the necessary equipment.

More importantly, though, movie suppliers seem poised to reach the PC user. This type of software being marked by huge amounts of data, movies on CD-ROM can only be marketed if there is a large potential of really fast PCs and ingenious program algorithms, simply because nobody will be satisfied with poor or irregular picture quality. To boost sales, many VGA cards are equipped with an MPEG decoder straight away. This decoder turns compressed data loaded from a CD-ROM into a viewable picture on the computer monitor. On some cards, the MPEG decoder is implemented by software only, on others, by hardware. The upshot is that they enable digitized movies, video-CDs or CD-i disks to be played and produce a quality which is, well, just tolerable. If you need to view videos on your PC, be sure to ask for a demonstration by your supplier, and gauge the quality you can expect.

NEW DEVELOPMENTS

The latest buzz in VGA land is 3-D video cards, a number of which are now available. It would be easy to welcome the addition of the third dimension to computer images because human sight naturally includes the perception of depth. As far as the computer is concerned, however, depth is only simulated. None the less, accurate CAD drawings with fantastic light effects, or games in an 'almost real' environment are impressive. Do not forget, however, that the technical effort to achieve all this presents an enormous technical overhead. To lighten the computing load of the main processor, special 3-D chips have been developed. Apart from specialists like 3Dlabs who offer professional as well as consumer-oriented (3-D Blaster) products in this area, other well-known manufacturers of graphic chips have released their own 3-D chip (including Matrox and S3). Others have announced to do so (ATI and Tseng Labs). Particularly with PC games, these improvements cause new alliances in the fiercely competitive market segment called computer gaming. Diamond, for instance, has added an integrated interface for Sega accessories on its 3-D accelerator called 'Edge'. (962008-1)

CORRECTIONS & UPDATES

Motor Controller for R/C models
(February 1997 - 960095)

The components list printed on page 18 should be amended to read
C3,C5 = 100nF, SMD
C4 = 10nF, SMD
C6 = 47μF 10V SMD
IC2 = L4940V5

PIC Controlled Home Alarm System
(April 1997 - 970022)

All PICs in the first batch we supplied to individual readers and kit dealers contain an incorrect oscillator code word which totally disables the device. These PICs are marked by the total absence of oscillator activity. Readers experiencing problems are requested to return the faulty PIC (order code 976501-1) to us for a free replacement. Please enclose a short note stating your name and return address, and ensure proper packaging.

Magnetic-Field Meter
(960100 - January 1997)

In the circuit diagram on page 28, R12 is incorrectly shown as a 10 kΩ resistor. The correct value is 22 kΩ 1%, as stated in the components list.

4-Channel Logic Analyser
(970042 - May 1997)

The program shown in Figure 3 has been tested under QBASIC 1.1 and QuickBASIC 4.5, not GW-BASIC as mentioned in the article. Because QuickBASIC is a compiler, it will produce a faster executable program than QBASIC. The highest signal speed the program can handle is mainly determined by the speed of the PC. Using a 486DX33 the maximum input signal frequency will be about 75 Hz under QBASIC 1.1, or about 20 Hz in 4-channel mode. The respective values for a Pentium 150 PC are about 250 Hz and 75 Hz. The use of QuickBASIC 4.5 will result in values which are about 6 times higher. The program will only work in a true DOS environment, i.e., not in a DOS box produced by Windows 95.
Finally, to obtain a calibrated timebase, simply apply a clock signal with a known frequency to one of the channels.

MExpress

A hands-on review

MExpress is a mathematical program which is very strong on graph and surface plotting in 2D and 3D, including animated graphics. The version of it reviewed here is MExpress 1.1 for Windows 3.1, Developers Edition. Versions are also available for Windows NT and Windows 95. The advantage of the Developers Edition over the cheaper Standard Edition is that it allows applications to be compiled into free-standing programs, using one of a number of popular C++ compilers.

By Owen Bishop

INTRODUCTION

MExpress has about 250 functions, including all the basic mathematical ones such as sine, log (natural and common), and square root. It also has a wide range of specialised mathematical functions in the fields of signal processing and statistical analysis, as well as those used for graphics. It has only one data type, the matrix, so that even a single variable or value is taken to be a 1 × 1 matrix. Matrices can contain integer, real, or imaginary variables or values, as well as text. This feature makes it much easier to use MExpress than some of the other packages that trip up the unwary with a multitude of data types.

Because we are reviewing this for *Elektor Electronics*, we decided to concentrate our attention on aspects of MExpress that are of special application to electronics. And because matrices are a dominant feature of this package, we first we set out to analyse the resistor network of **Figure 1**, using matrix techniques (see Reference 1). The three meshes of this network produce three simultaneous equations in which i_1, i_2 and i_3 are the mesh currents:

$$8i_1 - 3i_2 - 3i_3 = 4$$
$$3i_1 + 6i_2 - 3i_3 = 6$$
$$3i_1 - 3i_2 + 6i_3 = 0$$

Solving the network is a matter of solving these equations for the currents. The top half of **Figure 2** illustrates how it can be done as an on-the-spot MExpress calculation, performed on the **root screen**. We key in the coefficients of the left-hand side of the equations as a 3 × 3 matrix called *a*. We key in the values on the right-hand side as a 3 × 1 matrix, or vector, called *b*.

The ' symbol after the closing bracket indicates that the row matrix which has just been entered is to be transformed into a column matrix. The matrix is solved using the function **LUSolve**, which calcu-

1

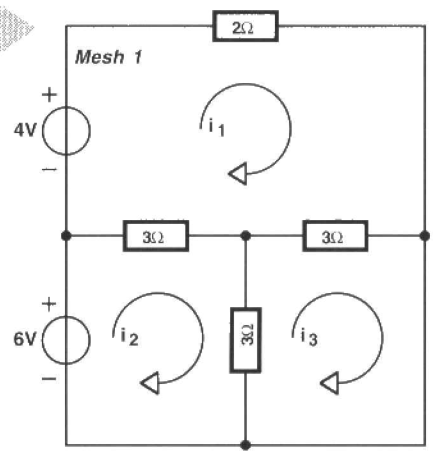


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Figure 1. A 3-mesh network for analysis by MExpress

2

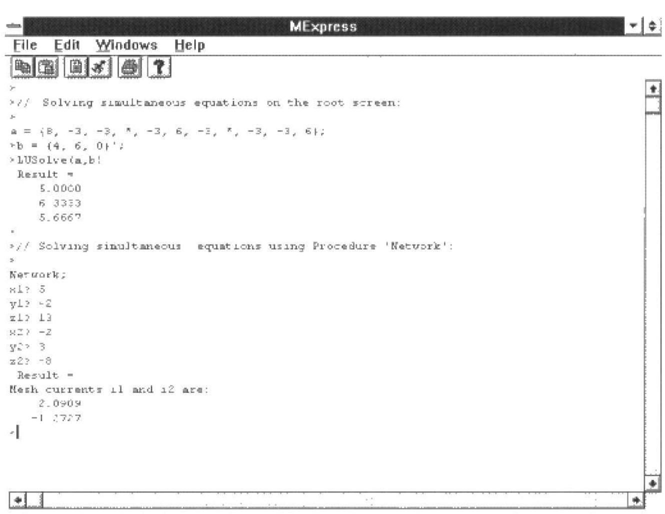

Figure 2. Analysis of the 3-mesh network in Figure 1 by matrix techniques.

lates and displays the output: $i_1 = 5$, $i_2 = 6.3333$ and $i_3 = 5.6667$. Values are in amps. This technique can be extended to networks with more than 3 meshes.

PROCEDURES

MExpress has a scripting language similar to BASIC, which means that users already familiar with BASIC will find little difficulty in becoming proficient in programming. Fortunately, the language includes provisions for functions and procedures. To try out this facility we wrote a short Procedure to analyse a 2-mesh circuit such as that in **Figure 3**. Analysis of a 3-mesh or greater network would just have been 'more of the same'.

Figure 4 shows our Procedure, called Network, as typed on to the computer's Notepad and subsequently saved as an '.X' file. Incidentally, MExpress comes with a whole library of .X files defining the more complicated functions. The figure shows how the Procedure resembles a segment of an ordinary BASIC program. We begin with the name and a list of parameters to be passed. Here we shall ask for the values of the coefficients to be typed in on the root screen, so the only parameter to be listed is *c*, the matrix containing the resulting currents.

The greater part of the Procedure is taken up with asking the user to enter the data. The Procedure than places this into the two matrices *a* and *b*. Next, the LUSolve function calculates matrix *c*. The Procedure is seen in action on the bottom half of the screen in **Figure 2**. The mesh equations are:

$$5i_1 - 2i_2 = 13$$
$$-2i_1 + 3i_2 = 8$$

We take the coefficients to be x1, y1, and z1 for the first equation and x2, y2, and z2 for the second. After entering the coefficients, the displayed result shows that $i_1 = 2.0909$A and $i_2 = -1.2727$A.

All we need to do is to type 'Network;' then key in the coefficients when asked. The next time we want to analyse a 2-mesh network, we do not have to worry about typing the right sort of (curly) brackets or remember to type in the * which delimits the rows of the matrices. All we do is type 'Network', key in the results when requested, and read the results a fraction of a second later. Functions and Procedures created in this way become part of the MExpress programming language and may be used just as easily as any of the functions provided in the software.

BODE PLOT

The transfer function of a low-pass single-stage passive *RC* filter at any given frequency *f* is $V_{out}/V_{in} = 1/[1+j(f/f_c)]$, where $j = \sqrt{-1}$ and f_c is the cut-off frequency or -3 dB point. In MExpress, j (as used in Electrical Engineering) is represented by the symbol **i** (as used in Mathematics). We

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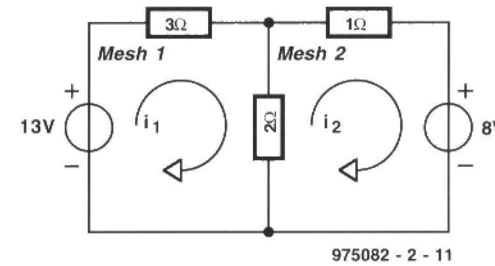

Figure 3. A 2-mesh network for analysis by an MExpress Procedure.

prepare for calculating the points by declaring a matrix to hold them, using *a*=Fill(1,1000,0). This fills a 1 row × 1000 column matrix with '0' in each cell. Next we fill each of these cells with a value calculated from the equation. If the frequency is to run from 1 Hz to 1000 Hz, $f_c = 200$ Hz, and the amplitude of V_{in} is 5 V, we evaluate

$$V_{out} = V_{in} / [5/(1+\mathbf{i}*(f/200)]$$

for each cell. This is done in a loop:

For *f* = 1 to 1000 do
a(f) = 5/[1+i*(*f*/200)];
End for;

Immediately this is typed in, matrix *a* is filled with values ready for plotting. However, these are complex numbers and we need only the real part to obtain amplitudes, so we use *a* = real(*a*) to retain only the real parts. All that remains is to plot the values on logarithmic scales, both for frequency and V_{out}. The Bode plot is quickly drawn (**Figure 5**). It has the typical low-

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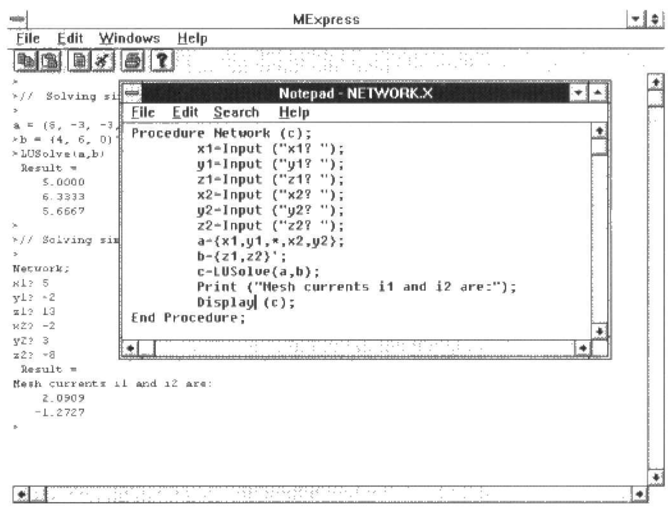

Figure 4. Network Procedure evolved by the reviewer.

Figure 5. The Bode plot has an unmistakable low-pass shape.

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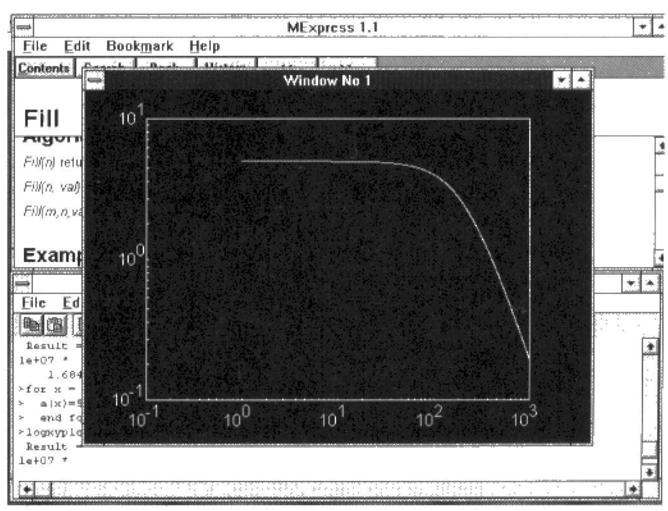

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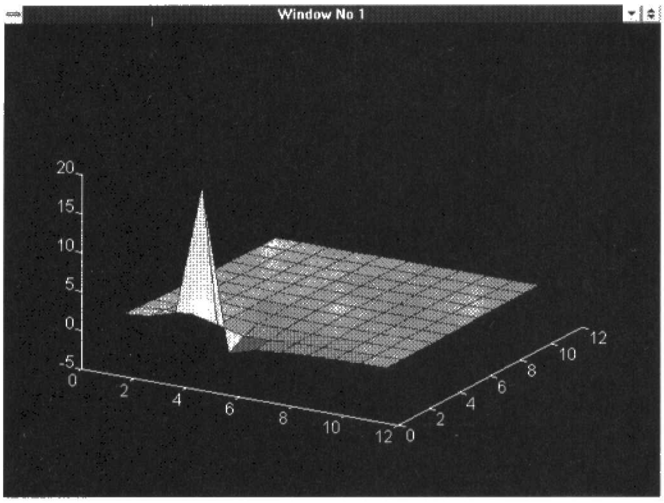

Figure 6. Plot of the transfer function of a single-stage passive high-pass filter.

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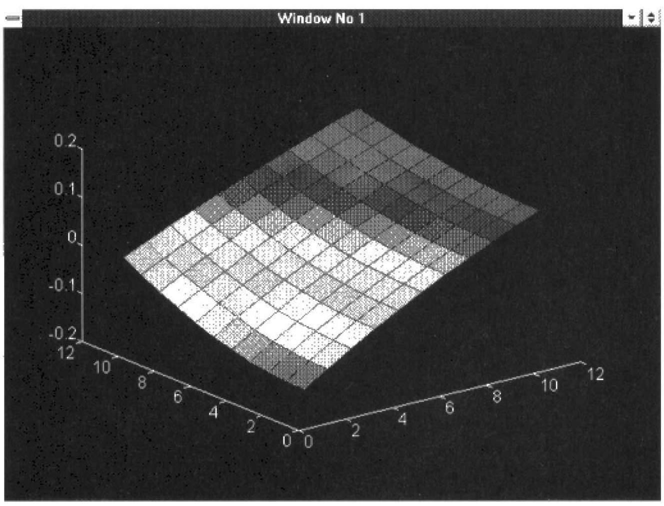

Figure 7. Plot of the same filter as in Figure 6, but with altered scales.

Figure 8. Histogram of number of flowers.

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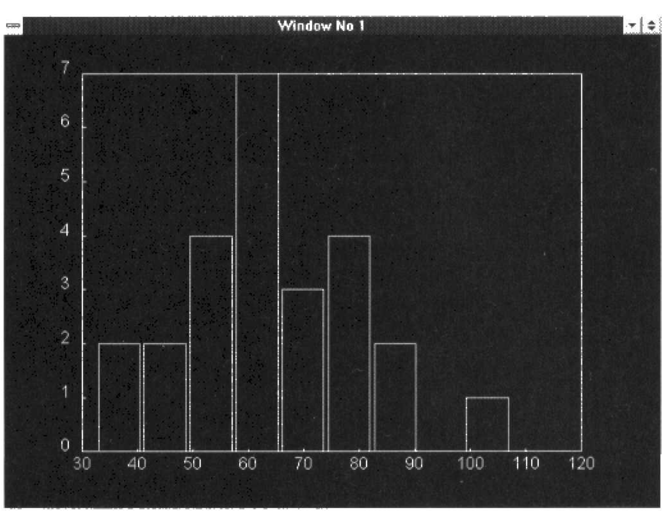

pass shape and it can be seen that the output amplitude is 3dB below the input amplitude at 200 Hz. This routine, too, could be made into a Procedure.

In passing, note the background in Figure 5. The top half of the screen is occupied by the MExpress tutorial supplied as the 'handbook'. In the bottom half of the screen is MExpress itself. This arrangement makes it very easy to learn how to use the program. Read a page of the tutorial, then use the bottom half of the screen to try out the commands. The tutorial provides a well-structured introduction to the program, with interesting and clear examples, including numerous graphics images where appropriate. It has a Contents page, hypertext jumps, and a helpful Search function.

The tutorial covers enough ground to get you started in most aspects of MExpress. If you want complete details of all the functions, you are provided with the MExpress Reference, which is a second help screen; its contents page lists all the functions in alphabetical order and you can jump from these to a page dealing with individual functions. Here you find details of syntax and operation, complete with examples. The Reference can be accessed directly from an icon in Program Manager, or by clicking on 'Help' in the toolbar of MExpress. In all, MExpress provides you with al the assistance you need to get your applications up and running.

TRANSFER FUNCTIONS

We often need to calculate these, so we tried to devise a way to plot them in 3D. The transfer function *tf* of a high-pass single-stage passive *RC* filter is given by:

$$tf = V_{out}/V_{in} = s/(s+\omega_0).$$

In this equation, ω_0 is the –3 dB cut-off angular frequency, and $s = \sigma + \mathbf{i}\omega$. Here s is the rate at which signal amplitude is changing (= 0 for a constant amplitude signal), and ω is its angular frequency. Thus, s is a complex number, but MExpress deals with complex numbers as readily as with real numbers. For explanations, see Reference 2. We worked out a Procedure for calculating all the values of V_{out} (given $V_{in} = 1$ and $\omega_0 = 5$) for 11 values of ω ranging from 0 to 30 and 11 values of s from –12.5 to +12.5, filling an 11 × 11 matrix *tf* with the results. The matrix is plotted in 3D, with the horizontal axes defining the s-plane and the vertical axis the magnitude of V_{out}. The result (**Figure 6**) shows some interesting features. One is a dip down to zero at $\omega = 0$ and $s = 0$. This is known as a 'zero', indicating a point at which the filter has zero output. The other more notable feature is the sharp peak at $\omega = 0$, $s = –10$. These are the values at which the transfer function exhibits an infinitely large value – a point of instability in the network. Points such as these are known as 'poles', and designers always try to make sure that a circuit is not required to oper-

ate in the region of a pole (unless the circuit is meant to be an oscillator, perhaps!). Note that the horizontal coordinates are scaled 1 to 11, representing the indices of the cells of the matrix. With a little extra programming the co-ordinates could be scaled to show values of ω and s instead, and the graph and axes can be styled and coloured in a variety of ways which we do not have space to show here. Figure 6 is plotted as a surface, but 3D graphs can also be plotted as a grid, either with or without hidden portions, and with all kinds of colour schemes. The angle of view can be set to obtain the clearest viewpoint.

As it happened, the calculation at the pole produced 'NaN' in the corresponding cell of the matrix. This stands for 'Not a Number'. Our program tested each cell and if it found a 'NaN' it substituted the value 20 in that cell. Thus the peak in Figure 6 is not as tall as it should be but, on the other hand, to make it any taller makes the rest of the plot too flat to show the zero.

Figure 7 is another plot of the same filter but with the scales reduced to 0–3 for ω and –1.25 to +1.25 for s, and with $\omega_0 = 10$. The pole is off this plot, but the zero is more clearly seen. The frequency (ω) axis runs toward the right and the right-hand edge of the surface shows the typical frequency response of a high-pass filter.

STATISTICS

To try out this useful set of functions we set up a matrix containing the numbers of flowers on 27 snapdragon (*Antirrhinum majus*) plants. The biggest work was typing in the data, but after that we could quickly use GetMax to find the largest number of flowers on a plant (111), and GetMin to find the smallest number (28). The function Mean told us that the mean number of flowers per plant was 62.889, and Median showed 59 to be the median number of flowers. All these results were obtained almost instantaneously, and the histogram of numbers of flowers (**Figure 8**) took only a little longer.

COMPILER

The fourth program (provided only with the Professional Version) is MExpress Compiler. This takes an *x*-file such as we produced for the Network analysis and translates it into C++. It is then compiled into a stand-alone executable, using one of the compatible compilers, Symantec C++ 7.0, Microsoft Visual C++, or Borland C++ 5.0. On the way there is scope to shine up the program by adding message screens, buttons, sliders, check-boxes and radio-buttons and, in general, to create a perfected product. We did not investigate the compiler, though look forward to using it in due course.

SUMMARY

We found MExpress and its auxiliary programs to be easy to understand, easy to use and reliable in action. So much of it is intuitive to the many who are familiar with BASIC, that it should be first choice as a maths utility. There appear to be no 'bugs' in it – everything worked for us 'as advertised'. It is a useful piece of software for anyone needing to do maths quickly, including the electronic designer, and represents good value for money.

[975082-2]

References

1) Owen Bishop (1993), *Understand Electrical and Electronics Maths*, Chapter 13. Newnes, ISBN 0 7506 0924 9.
2) Owen Bishop (1996), *Understand Electronic Filters*, Newnes, ISBN0 7506 2628 3.

Capacitors

Capacitors come in many sizes, shapes and makes. Not many audio enthusiasts realize how great an influence capacitors have on the sound quality throughout the whole audio chain from coupling capacitors to filter capacitors. This article takes a look at the most important properties of these passive components.

By our Editorial Staff

INTRODUCTION

Bipolar electrolytics, polyester film, polycarbonate, polypropylene, polystyrene, smooth film, coarse film, the descriptions of capacitors seem endless. Most of us know that there are many differences between all these kinds of capacitor. But what are those differences, can they be measured, and, most importantly, for what applications can they be used? In this article we will not just look at the differences in quality, but also which factors play a role in the operation of a particular capacitor and which capacitors give the best results in audio applications.

OPERATION OF CAPACITORS

We will not delve too deeply into the operation of capacitors, but confine ourselves to general and basic factors.

Basically, a capacitor is a device that has capacitance, which is the ability to store electrically separated charges when a potential difference exists between the conductors. It consists of two conductors or semiconductors separated by an insulator called the dielectric. The name of the dielectric becomes the name of the capacitor, that is, when the dielectric is paper, the capacitor is called a paper capacitor. The conductors or semiconductors are known as electrodes or plates. The value of the capacitance depends on the size and shape of the plates, the separation between them and the relative permittivity of the dielectric. The permittivity, e, indicates the degree to which the dielectric can resist the flow of electric charge and is always greater than unity; it is the ratio of electric displacement in a dielectric and the applied electric field strength. The relative permittivity, e_r, is the ratio of the electric displacement in the dielectric to the electric displacement in free space, e_0, for the same value of applied electric field strength, i.e., $e_r = e/e_0$. Note that e_r is called the dielectric constant when it is independent of electric field strength.

The value of the capacitance, C, in picofarads is

$$C = 0.0885\, e_r A / d\,,$$

where A is the area of each plate in cm^2, e_r is the relative permittivity, and d is the distance between the plates in cm.

This equation shows that the capacitance may be increased by reducing the distance between the plates, by enlarging the plates, or by replacing the dielectric by one with a larger relative permittivity. The dielectric constant for a variety of capacitor materials is given in **Table 1**.

The distance between the plates and the dielectric used determine the breakdown voltage of the capacitor. The size of a capacitor is determined not only by the capacitance, but also the working voltage, the dielectric, and the type of construction.

According to theory, an ideal capacitor would have a reactance, X_C of

$$X_C = 1/2\pi fC,$$

but, unfortunately, reality is rather more complex. The equivalent circuit of a capacitor is shown in **Figure 1** – this is a standard schematic used in hundreds of textbooks with the exception of the components in dashed lines which are less familiar but which nevertheless play a role in the operation of capacitors. There are much more complex schematic diagrams of the equivalent circuit of a capacitor which take into account factors such as the hysteresis in the dielectric, but these have no place in

a brief overview such as this.

In Figure 1, C is the capacitance proper. It is shunted by resistor R_p, which is the insulating resistance of the dielectric. Normally R_p has a value of tens of megohms, so it is usally not taken into account.

The series resistor, R_s, represents the minimum transfer resistance between leads, plates and dielectric. The reactance of a capacitor can never be lower than the value of R_s. This resistance is an important factor in low-impedance circuits in which large currents flow – such as in cross-over networks.

The value of the series inductance, L_s, depends on the construction of the capacitor (rolled-up plates), the terminal leads, and the manner in which these are connected to the plates (at one point or over a large area of the plates).

Components C_{DA} and R_{DA} represent the dielectric absorption, *DA*, which is a less well-known property of capacitors. If the dielectric were an ideal material, no energy would be lost from an electric field applied across it. In reality, electric hysteresis losses occur. The charge displacement, *D*, lags behind the applied field, *E*, resulting in a typical hysteresis curve and energy losses from the applied field, which appear in the form of heat. Dielectric absorption has an appreciable effect on the sound quality.

The impedance vs frequency characteristic of a capacitor is shown in **Figure 2**. With increasing frequency the impedance drops until the resonant frequency, f_r, is reached, after which the impedance increases again owing to the presence of L_s. The resonant frequency is determined by

$$f_r = 1/2\pi\sqrt{(L_sC)}.$$

The minimum impedance at f_r is about equal to R_s. Note, however, that most components in Figure 1 are frequency-dependent to some extent.

The specification of a capacitor normally states the following.

- ✓ The dissipation factor, which is the cotangent of the phase angle, α, or the tangent of the loss angle, δ. It indicates the losses in the capacitor owing to R_s. Sometimes Q is stated: $Q = 1/2\pi f C R_s = 1/\tan\delta$.
- ✓ The insulation resistance, R_p, which is normally very high.
- ✓ The power factor, which indicates the dissipation in the capacitor. It is equal to the cosine of the phase angle: p.f. $= \cos\alpha = R_s / Z = \sin\delta$, where Z is the total impedance.
- ✓ The temperature coefficient – this will be reverted to later in this article.
- ✓ The value of the capacitance, normally measured at 1 kHz (but a higher one in case of h.f. capacitors).
- ✓ In case of large electrolytic capacitors, the ESR (equivalent series resistance), R_s.

Table 1. Relative dielectric constant of various materials

Material	ε_r
aluminium oxide	*7–8*
ceramic	*≥ 10*
glass	*4–10*
air	*1.0001*
mica	*6–8*
paper	*2–5*
pertinax	*5*
polycarbonate (MKC)	*3*
polyester (MKT)	*3.0–3.2*
polypropylene (MKP)	*2.1–2.3*
polystyrene (MKS)	*2.5*
porcelain	*4–8*
tantalum oxide	*11*
teflon	*2.0–2.1*

CONSTRUCTION OF CAPACITORS

A practical capacitor can, of course, not just consist of two large plates separated by a dielectric. So, over the years manufacturers have devised many different methods of obtaining as much capacitance as possible from as compact a construction as feasible. In this article we will look only at those constructions that are of interest to audio engineering.

A modern capacitor is normally formed by a number of stacked or twisted layers. In the case of film capacitors, the electrodes are usually made of thin metal foil vaporized on to the dielectric, whence the capacitor is called a metallized-film type. During the stacking or winding of the electrodes, the layers are slightly displaced w.r.t. one another to enable the terminal leads to be connected to them. In modern film capacitors, these leads are sintered on to the entire protruding part, as distinct from at one point, of the electrode. This results in wound capacitors having no more self-inductance than stacked types.

Electrolytic capacitors have the largest capacitance per unit volume. They consist of two plates separated by a (partially) liquid electrolyte. One of the electrodes is given a film of aluminium oxide that acts as the dielectric. This layer may be applied in various ways. In case of a so-called coarse film, the upper surface aluminium oxide is chemically roughened so that the total area of the layer, and thus the capacitance, is much larger. In an electrolytic capacitor of the same dimensions, but with a smooth film, the total area, and thus the capacitance, is appreciably smaller.

In tantalum capacitors, the anode is given a tantalum oxide film which is covered with a fixed electrolyte of manganese dioxide, which functions as the cathode. Years ago, tantalum capacitors were used in audio circuits,

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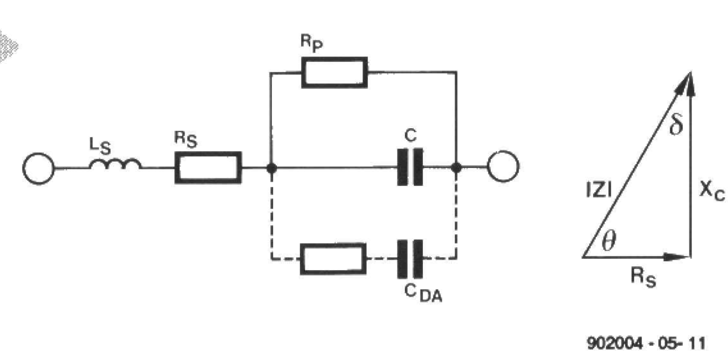


Figure 1. This equivalent circuit of a capacitor is a standard schematic used in a multitude of textbooks.

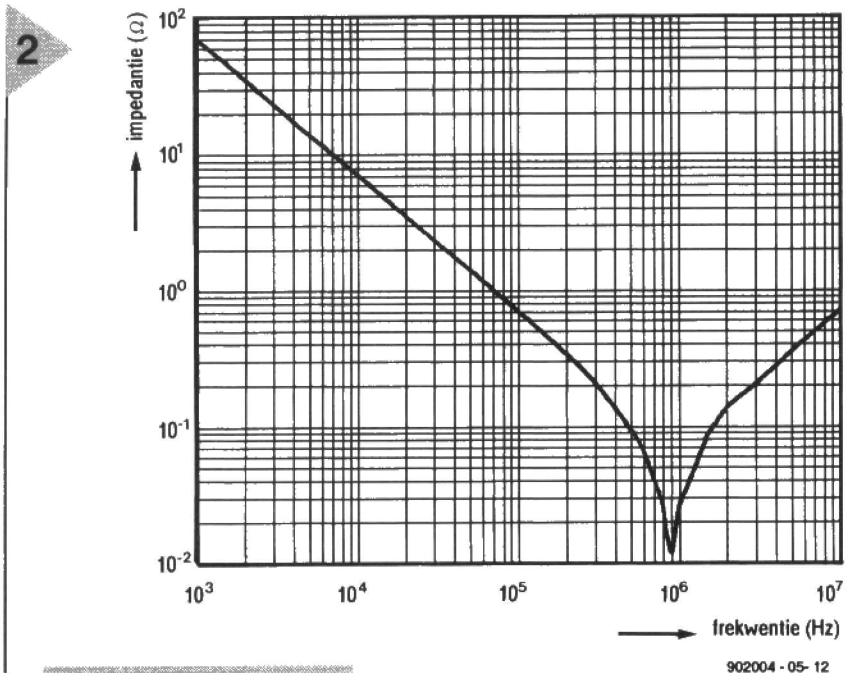


Figure 2. Impedance vs frequency characteristic of a capacitor.

but, owing to their semiconductor effect, they are not really suitable for this: they should be used only in power supply lines.

MATERIALS

Capacitors commercially available may be divided into some large groups according to their dielectric:

- ✓ film capacitors;
- ✓ ceramic capacitors;
- ✓ mica capacitors;
- ✓ electrolytic capacitors;
- ✓ paper capacitors.

Paper capacitors are hardly available nowadays; once upon a time they were in frequent use in cross-over networks.

Ceramic capacitors are not of much interest for low-frequency applications, since they are not generally available in suitable values; there are types available in values up to a few microfarads, but these introduce rather a lot of distortion.

Mica capacitors are generally available only in small values: up to about 0.01 μF.

The most common, and least expensive, film capacitors are polyester (including polyethylene-teraphtalate) types. These possess generally good properties and may be used in most applications where good quality is required. They are available in values up to about 100 μF with tolerances of 1–20 per cent.

Polycarbonate capacitors are not often used in audio engineering, but the dielectric is excellent with rather better properties than polyester. Capacitance drift as a function of temperature is much smaller than in polyester capacitors.

Polypropylene has even better characteristics than the previous two, but owing to the rather lower dielectric constant, these capacitors tend to be somewhat larger. The dissipation factor and the dielectric absorption are smaller than in the previous two materials.

Polystyrene capacitors are undoubtedly the best film capacitors for audio applications. They have an excellent temperature performance, low losses and very small dielectric absorption. Unfortunately, they are available in only small values – up to 0.5 μF – and they are relatively large.

Aluminium electrolytic capacitors used in electronics are primarily of the so-called wet variety. Their properties make them eminently suitable for use in low-frequency and non-critical applications. Unfortunately, their tolerance is asymmetric, normally from +80% to –20%. Moderate stability and a limited life preclude their use in high-quality applications. Apart from that, they need a direct voltage.

Other than the usual unipolar types (with a +ve and a –ve terminal), there are bipolar types (which are not sensitive to the polarity of the direct voltage). The bipolar types are subdivided into those with a coarse film and those with a smooth film. Both these types have a smaller, and usually symmetric, tolerance of about ±10 per cent, and generally better properties than standard electrolytic capacitors.

The dissipation factor and dielectric absorption of electrolytic (and tantalum) capacitors are fairly large.

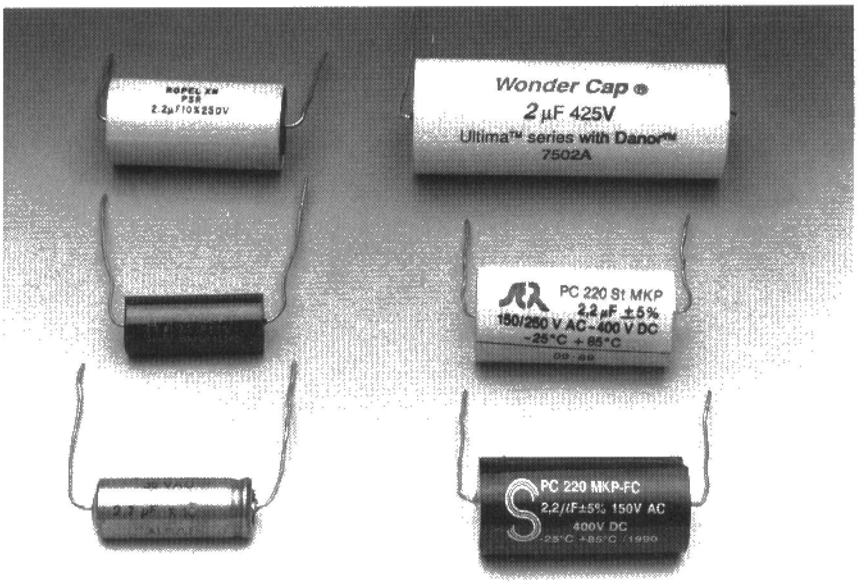
CAN THE DIFFERENCES BE MEASURED?

The answer to the question is 'yes', but the equipment required is frightfully expensive. With a Type 4284 RLC Meter (on loan from Hewlett Packard) and an Audio Precision System One Analyser with integral FFT Analyser and a HP3325A Synthesizer Function Generator, we were able to carry out a wide range of measurements on a number of different types of capacitor.

The most important of these measurements are grouped in **Table 2**. We have tried to use capacitors throughout of the same value – 2.2 μF. For each capacitor the real value at 1 kHz is given. Series resistance R_s and the dissipation factor, tanδ, are measured at 100 Hz, 1 kHz, and 10 kHz. Basically, of course, R_s, may be computed from tanδ. Harmonic distortion was measured at 250 Hz if the capacitor was used in a high-pass *RC* filter (f_c = 1 kHz). It is likely that the distortion is caused by the frequency-dependent performance of the capacitors and the pres-

Table 2 Measurement results

Type of capacitor	capacity (μF)	Rs (Ω)			D			THD (%) (3 V)	DA (%)
		100 Hz	1 kHz	10 kHz	100 Hz	1 kHz	10 kHz		
MKP	2.20	0.10	0.015	0.01	0.0001	0.0002	0.0017	<0.001	<0.01
MKC	2.19	0.42	0.07	0.02	0.0006	0.0010	0.0031	<0.001	0.03
MKT	2.17	1.27	0.32	0.075	0.0017	0.0044	0.010	<0.001	0.09
El_{smooth}	2.21	44.9	3.86	0.040	0.069	0.053	0.052	0.012	3.3
El_{coarse}	2.32	15.5	5.43	0.92	0.024	0.08	0.117	0.003	0.63



sures between the films caused by the prevalent differences in charge.

The dielectric absorption is given as a percentage. This is obtained in a static test in which the capacitor is charged for some time, then discharged rapidly, after which the increasing residual voltage is measured.

Of each type of capacitor, examples from different manufacturers were tested. All values have been averaged over a number of types and rounded off.

The self-inductance of all capacitors was measured, but not given in the table since the values were in all cases below 50 nH, which is negligible for applications in cross-over filters. It was noted that the self-inductance was caused mainly by the shape of the terminals leads and not by the capacitors themselves.

The table shows clearly that polypropylene (MKP) capacitors were best, closely followed by polycarbonate (MKC) types. Polyester (MKT) capacitors also came out very well.

For interest's sake, electrolytic capacitors were included in the tests: the results do not agree with the opinion of a number of audio enthusiasts who maintain that smooth film type electrolytic capacitors have better properties than coarse film types. Our tests show exactly the opposite. However, up to 500 Hz, there is little to choose between the two types: they are relatively poor and the distortion at large a.c. levels (≥ 10 V r.m.s.) across the capacitor increases to 0.1%. Bipolar types should only be used if absolutely unavoidable.

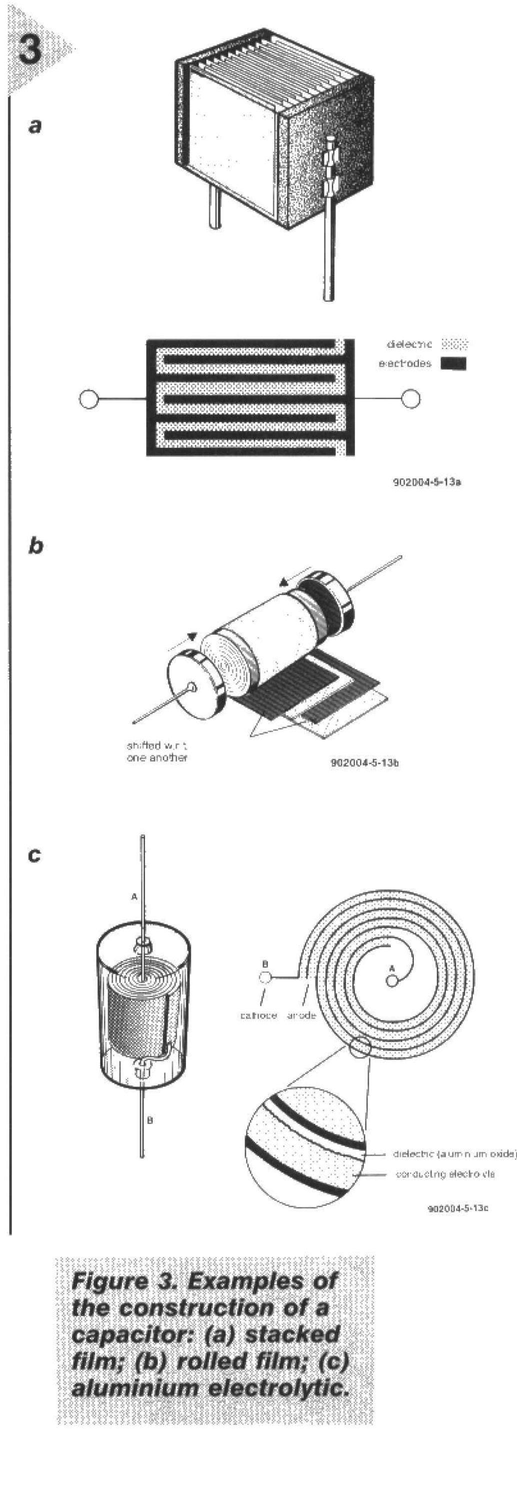
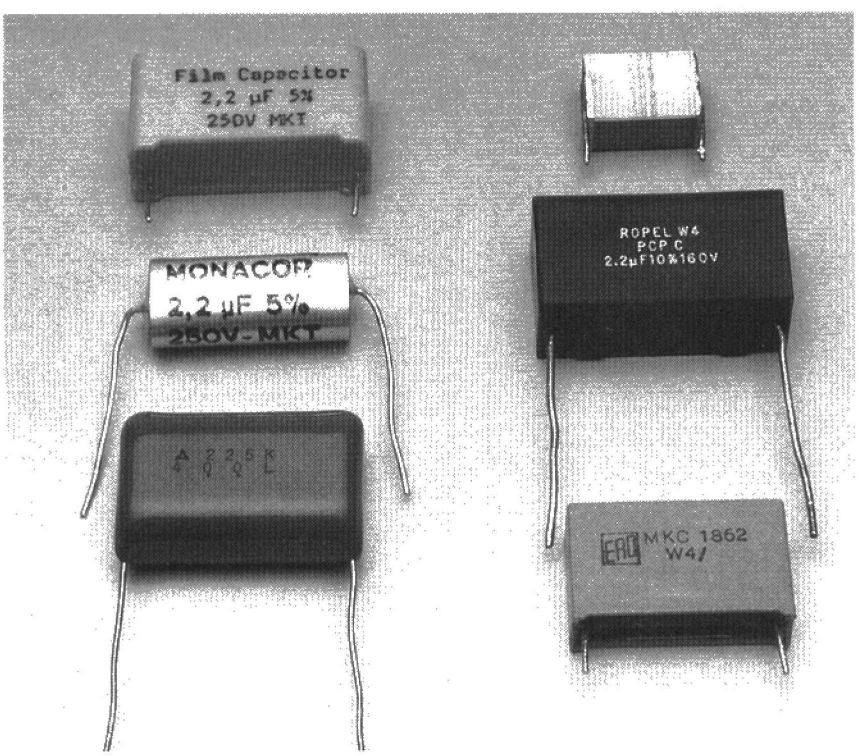


Figure 3. Examples of the construction of a capacitor: (a) stacked film; (b) rolled film; (c) aluminium electrolytic.



SUMMARY

The quality of capacitors is, from high to low: polypropylene (MKP); polycarbonate (MKC); polyester (MKT), and electrolytic. Both smooth-film and coarse-film electrolytic capacitors did badly on the tests – they should be used only in non-critical circuits. Remarkable was the small spread of the film capacitors from various manufacturers. Our tests show that stories such as "I can tell the difference between a polyester capacitor from manufacturer A and one from manufacturer B" should definitely be taken with a pinch of salt.

[ES – 975084/1]

Bell and Edison

Application vs inspiration

A double 150th anniversary

This year marks the 150th anniversary of the birth of two men who did more to bring about this century's communications revolution than anyone. Although contrasting personalities, they would have an effective, if detached, influence on each other's major inventions: the gramophone and the telephone.

By Greg Grant

INSPIRATION

Thomas Alva Edison could not cope with a formal education. Born on the 11th February 1847 in Milan, Ohio, his school teachers described him as 'addled.' By the time he was 12 his mother had had enough. She pulled him out of school and educated him at home.

He finally began his working life as a boy telegraph operator during the American Civil War. In the course of this work he met Samuel Morse, inventor of the eponymous code, which made the telegraph the first successful long-distance communications system.

Artist, sculptor, designer, and, indeed, the founder and first president of the American National Academy of Design, Morse had another talent which lastingly impressed the young Edison: his skill and success as a business promotor and fund raiser.

This was the man who had helped raise $350,000 in two weeks to create the Atlantic Telegraphic Company which, in 1958, laid the first Atlantic Telegraph cable.

Consequently, it's no accident or chance that Edison's first commercial phonograph was called the 'Triumph'. If there was one lesson he'd learned from Morse, it was that marketing and the promotion of your products mattered, and mattered greatly.

By the age of 22, this educational failure had invented the Ticker Tape machine, which he sold for $40,000, an almost unbelievable sum at that time. This achievement enabled him to become professionally what he had long been personally: independent. A decade later, his improvement to the telephone brought him even more money. He promptly moved from New York to Newark, New Jersey, where he set up his own laboratory at Menlo Park.

This establishment was the prototype of all future electronic laboratories, although it differed in one respect. It promoted and developed the ideas of only one man: its owner.

Edison was serendipitous. He would break off a particular train of work when it threw up some unexpected discovery or phenomenon, so as to work on this new track. He readily admitted for example that, at the time of his experiments with household lighting, he had no idea how Ohm's Law operated.

He equally acknowledged that figures were the last thing he depended on. When asked for example how many experiments he had carried out in the course of developing a Storage battery, he replied that it must have been close to 50,000 over a decade or thereabouts. This meant that, in financial terms, the Edison Storage Battery cost some $3,000,000 to develop!

Edison supposedly said that genius was one per cent inspiration and ninety-nine per cent perspiration. This in fact was a fairly accurate description of his working methods, for his system turned what was rapidly becoming standard scientific practice on its head. In other words, instead of pure research leading to applied research, Edison began with the latter and even-

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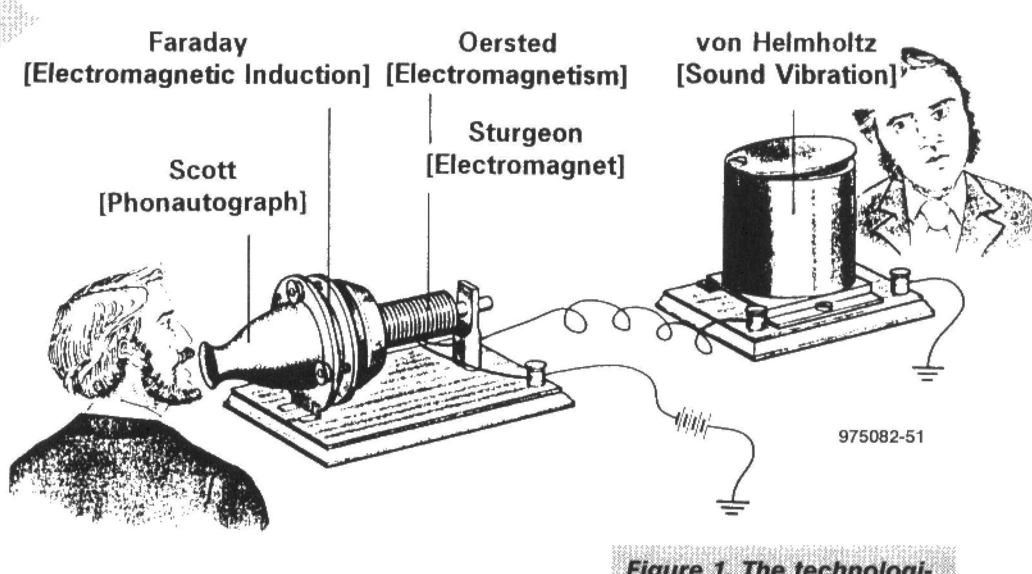


Figure 1. The technological foundations that made the telephone possible.

tually arrived at the former.

It was this approach that so annoyed one of his employees, a bright young electrical engineer called Nickoli Tesla. He pointed out that Edison could have saved himself a great deal of time and effort by applying mathematics and a lot more thought and organisation to what he was doing. This however was not the self-made Edison's way, and so Tesla sought a position elsewhere.

That this was hardly the best way to go about the business of invention is borne out by the patent record. Provided that is, you look beyond the glitter. Edison filed 1,093 patents: of that there is no dispute. They covered the invention of - and improvements to - the Telegraph, Motion Pictures, Batteries, the Gramophone, the Power Generator and the Telephone. This is the glitter, much quoted in articles, papers and books.

The above figure, whilst undeniably impressive, looks somewhat less so on closer inspection. No fewer than 389 of Edison's patents relate to improvements to his Electric Light Bulb and Power Generation.

Another 195 were needed before he got his gramophone - or Phonograph as he termed it - working satisfactorily and his improvements to the Telephone required a further 34 patents. This meant that some 618 patents, around 58% of the total, were taken up with improvements to four devices. The only conclusion to be drawn from this is that, throughout his working life, Edison had trouble developing his design ideas.

APPLICATION

Alexander Graham Bell* on the other hand had no such difficulty. Born in Edinburgh on the 3rd of March 1847, within a month of Edison, Bell came from a family that had a long association with the study of speech and elocution. He studied at University College London before emigrating to Canada in 1870 and, shortly afterwards, to the United States of America. In 1872 he founded the Boston School for the Deaf, to train teachers in this field.

Bell knew that sound waves expanded and compressed the air through which they passed. His ambition was to use the waves in a way such that they could be converted into a fluctuating electric current which, having been transmitted along a wire to a distant location, could be converted back into sound. He saw an application for such a device in his work with the deaf.

In his development work towards this device however, Bell did not invent per se. Instead he collated several disparate discoveries into a working system which gave what he wanted.

The discoveries were those of Hans Oersted, William Sturgeon, Michael Faraday, Hermann von Helmholtz and the Frenchman Leon Scott, all of them illustrated in **Figure 1**.

In 1875, Bell demonstrated how he differed from Edison in his approach to developing ideas. Instead of profligacy with time and dollars, he asked his friends at the Massachusetts Institute of Technology, (MIT), to educate him on the theory behind the work of the men whose discoveries he was fusing into a viable device.

Bell's telephone first appeared in public at the Philadelphia Centennial Exhibition in 1876. Bell promptly filed for a patent - No. 174,465 - which remains the single most lucrative patent ever issued. The telephone patent was the first of 18 granted to Bell in his name alone. He would also be granted a further 12 in association with collaborators, a total of 30 in all. Of this total 14, or almost 47%, dealt with the telephone alone.

In inventive terms it was 'Inspiration along the Way' that motivated Edison. In Bell's case the drive came from an adherence to basic principles, the application of what was known. Edison spent a great deal of time improving what was already there, inventions he himself had made and those of others. Bell rarely, if at all, made refinements to what was already there except, of course, to his original invention.

Yet paradoxically, in the decade between 1876 and 1886, both men would improve, indeed make more economically and industrially viable, the major communicative invention of the other. For Edison this was but standard practice: for Bell however it was something of a departure.

In 1877 Edison invented the Carbon Granule Microphone, illustrated in **Figure 2**.

This made Bell's invention a truly practical device and, in its many forms, this microphone would remain the preferred choice of telephone equipment manufacturers well into the 1960s. Nine years later Bell demonstrated that his refining abilities were by no means restricted to the telephone when he greatly improved Edison's Phonograph. He replaced the drum with wax disks and used an engraving needle and a controlled speed.

This was the beginning of Acoustic Information Storage, or AIS. Indeed Bell's system - improved along the way by Peter Goldmark's Long Playing disk of the early 1950s - has only recently been replaced by a new technological development, the Compact Disk, or CD.

2

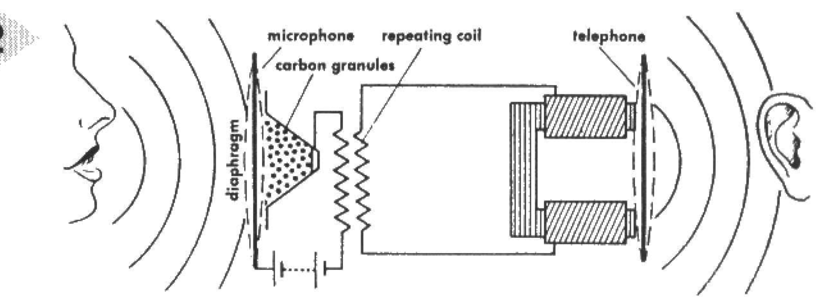


Figure 2. Edison's carbon granule microphone made Bell's telephone a practical device.

Although they differed in their approach to invention, both men shared a characteristic common to scientists and engineers before and since. They had no real idea as to how, or for what purpose, many of their inventions would be used.

Edison, whilst aware that the phonograph could record music, stressed in his advertisements that it would be an ideal instrument for recording the last words of the dying!

The telephone, too, was perceived to have a multiplicity of uses, quite apart from its obvious one in commerce generally. Yet Bell's greatest hope for it was that it would be used to enable all Americans to sing *The Star Spangled Banner*† in unison!

Even great inventors it seems lack inspiration and application in some areas!

[972008-1]

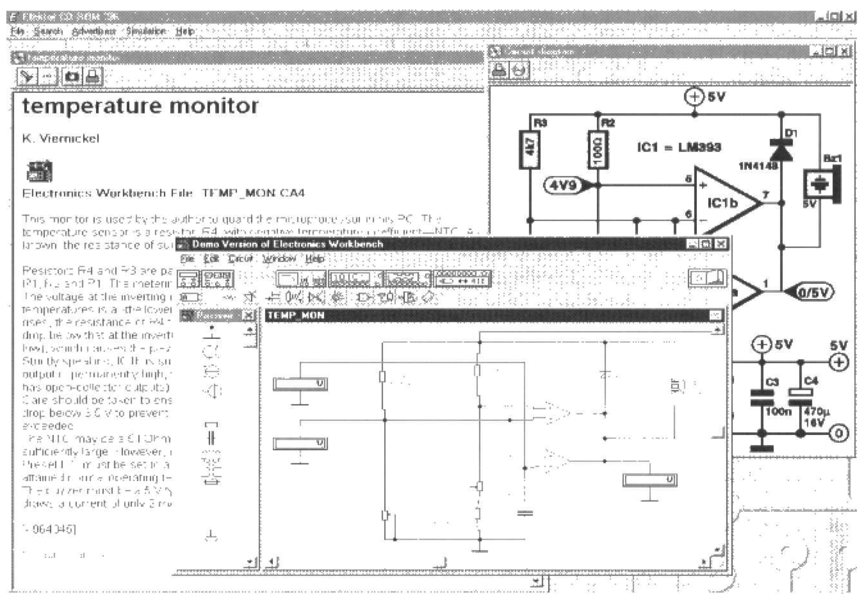
* See New Books elsewhere in this issue for a review of a new biography of A.G. Bell.

† The national anthem of the United States of America. It is based on a poem written by Francis Scott Key in September, 1814, and set by him to the melody of the English song *To Anacreon in Heaven*. It was not officially adopted by the U.S. Congress until 1931. [Editor]

Volume 1996 on CD-ROM

now includes circuit simulation options

Good news for all of you who like to *have Elektor Electronics* magazine in electronic form: the second CD-ROM covering a whole year's content (eleven issues) of *Elektor Electronics* magazine is now available! Apart from all published construction and background articles (in four languages) the CD-ROM also contains a free bonus: a working demo of the Electronics Workbench, allowing you simulate circuits for yourself.



With the release of this CD-ROM we offer our readers another volume of *Elektor Electronics* in electronic form. All editorial articles (except the News and New Products sections) are found on the CD-ROM, including all illustrations and PCB layouts.

A program which was specially designed for this CD-ROM (and perfected over the past few years) combines good legibility of the articles with the demands of today's electronic engineer in respect of quality of the circuit diagrams and PCB layouts. This program is probably unique because a standard viewer is usually employed for these applications, leaving much to be desired as far as quality and organisation of the material are concerned.

What can you do with the CD-ROM 1996, and how do you use it? If you already have the previous volume (1995), there's little to tell you. Those of you who have never seen an *Elektor Electronics* volume CD-ROM, however, may like to know what to expect from this year's release.

After launching the program from CD-ROM (that's right, the program does not have to be installed, and does not use hard disk space), you first select the language. Next, the main menu presents you with an overview of all articles published in 1996, arranged in categories. This window allows you to open any individual article, or go to a month overview. On opening an article, a text window appears which may also contain illustration photographs. While reading the article you may open one or more new windows containing schematics, PCB layouts, tables, insets or component lists, as required. To open such an illustration, you simply double-click on the hyperlinks marked in red in the article text. It is also possible to call up an overview of all windows related to the article by right-clicking at any point in the text window, and then pick the desired item from the list which pops up.

The program offers a number of search options. If no article is opened, the menu option 'search' allows you to search all articles for a certain word or number. It is possible to include a number of months only in the search. This search option is useful for locating projects which make use of a certain component you want to know more about. If an article is already open, the search function works in the relevant text only (including any insets and parts list).

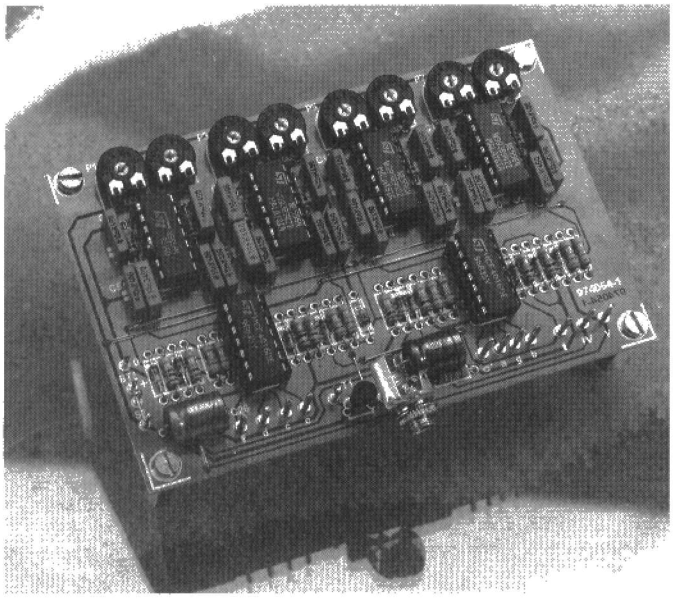
In windows containing a circuit diagram or a PCB layout, you can zoom in and out simply by clicking the left and right mouse button, respectively. All circuit diagrams are available on the CD-ROM at a resolution of 300 dpi (dots per inch). PCB layouts have a resolution of 600 dpi which enables you to run off high-quality copies on a laser printer. All schematics, layouts and texts may, of course, be printed, but it is also possible to copy text sections to a word processor for use in, say, a report (not forgetting to mention *Elektor Electronics* as the source, of course).

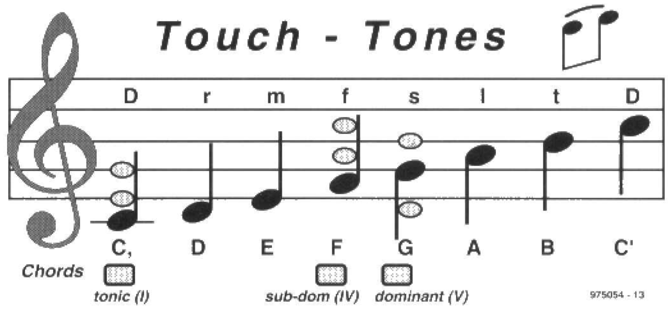
This year's volume on CD-ROM contains a free bonus in the form of a working demo of **Electronics Workbench**. This program enables you to test (*Elektor Electronics*) circuits without the use of a soldering iron. A couple of examples of simulation schematics derived from Elektor circuits are available on the CD-ROM to get you going.

The CD-ROM Elektor 1996 we reckon should be highly recommended to anyone with an interest in electronics and computers. As a matter of course, you should have a Windows PC and a CD-ROM drive to be able to use this product.

The price of the CD-ROM Elektor Volume 1996 is £31.50 for subscribers and £35.50 for other readers. (970058)

musical touch-tones



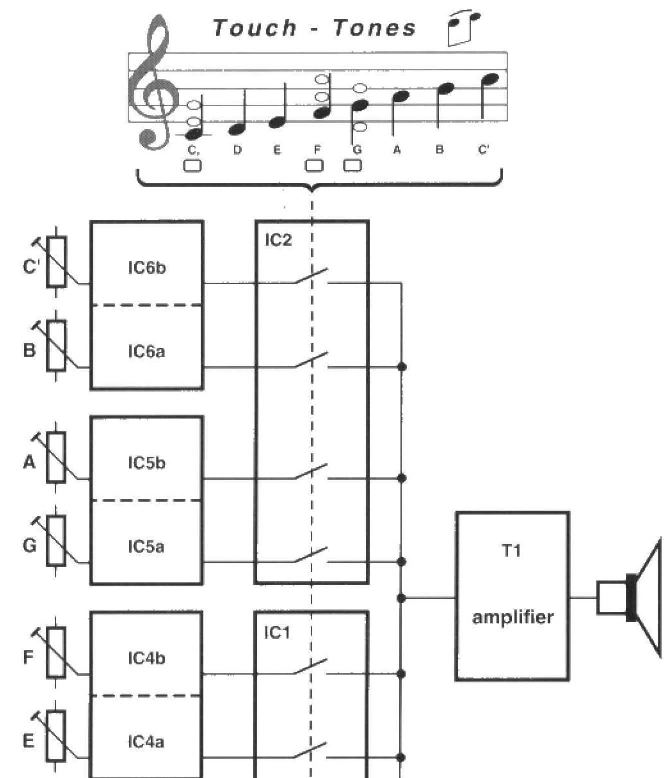


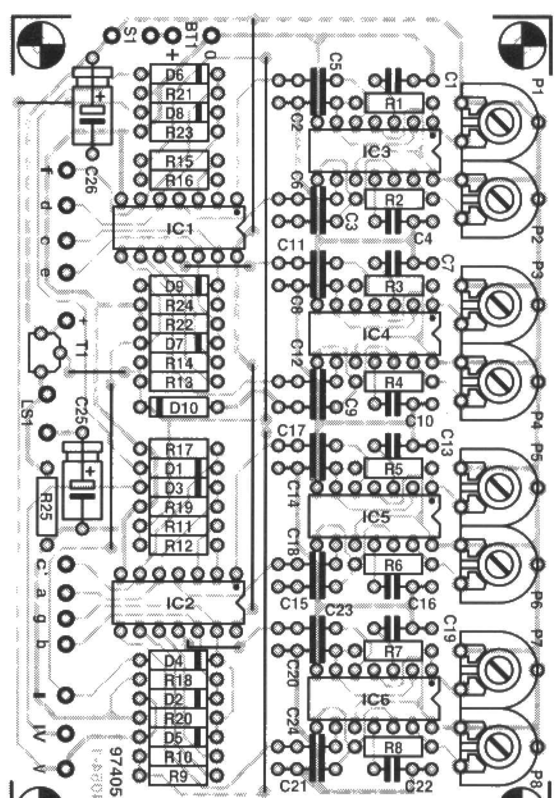
Those tadpole-like notes, on or between five horizontal parallel lines known as a staff, have been around for nearly a thousand years. Whatever instrument you play, whether it is blown, beaten scraped or plucked, uses this musical notation to indicate the pitch of notes (i.e., how low or high they are), the rhythmic pattern and note values. The problem is that the budding musician still has to translate this musical shorthand into the mechanical movements necessary for playing the particular instrument. Surprisingly, over the years, few conventional instruments have been designed to resemble this musical notation system, although keyboard instruments come closest.

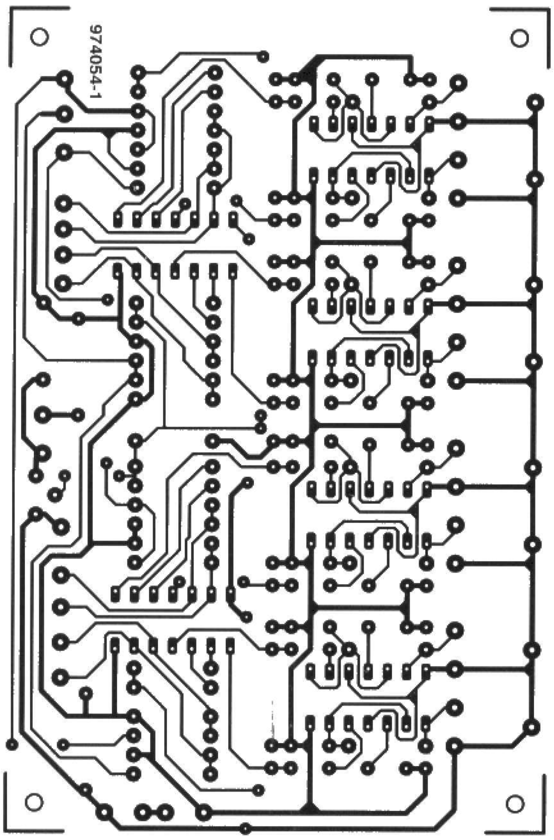
Electronic Touch-Tones offer both the sight and sound of musical notation. Although this project is limited to a one-octave major scale, it indicates a method of transforming written notation directly into sound. Moreover, it provides a useful teaching aid for youngsters learning the basics of scales, intervals and primary chords.

The block diagram shows eight oscillators, their tuning controls and two quad analogue switch ICs feeding a transistor output stage. As indicated on the staff, three primary chord touch plates are available, providing a basic accompaniment for any of the notes in this major scale.

In the circuit diagram, things may look complex at first, until you realize that there are eight identical oscillators, two per 556 IC. Let's look at IC3. For one half of the twin oscillator chip, the frequency of oscillation is controlled by RC network P1-R1-C1. With the values given, several octaves are available by adjustment of P1. The oscillator output signal is capacitively coupled to pin 1 of IC1, i.e. one of four identical analogue switches. When the C, note on the front panel scale is touched by a fingertip, the skin resistance enables the analogue switch. Each note has two adjacent wires, one to 0V and the other to the enable pin on the analogue switch. This routes IC1 pin 1 to pin 2, and the low-C oscillator







output is applied via R16 to the base of output transistor T1.

All eight oscillators operate in similar fashion to the one described.

Note that diodes D1-D9 connect the three front panel chord touch-plates to the appropriate analogue touch controls in order to sound the three primary triads; tonic (I) to C, E and G; sub-dominant (IV) to F, A and C'; and dominant (V) to G, B and D. The diodes serve to connect and isolate the touch-plates; the cathodes of the diodes must connect with the touch-tone wires that go with the analogue switches.

The circuit is best built on the PCB shown here (not available ready-made through the Readers Services). Use flexible ribbon leads for the analogue switch connections to the front-panel touch wires, the battery and switch connections, and the speaker leads. I mounted the computer-printed scale between a paxolin panel and a thin sheet of perspex (260×110 mm) for protection, Each touch-tone consisted of two short parallel gold-plated wires, the upper connected to the appropriate analogue switch enable contact, and the other to the + supply rail. The front panel was attached by wood screws to a shallow plywood box (40 mm deep) that houses the PCB and the battery. The miniature loudspeaker was glued behind the treble clef on the front panel with small holes drilled to emit the sound. Current consumption was approximately 20 mA, so a PP3 battery was adequate.

The eight presets in the circuit should be tuned against a keyboard or other musical instrument that is available. Finally, although this simple eight-note version is limited, the idea could easily be extended to the chromatic scale of twelve semitones and further.

(974054 - R Beddington)

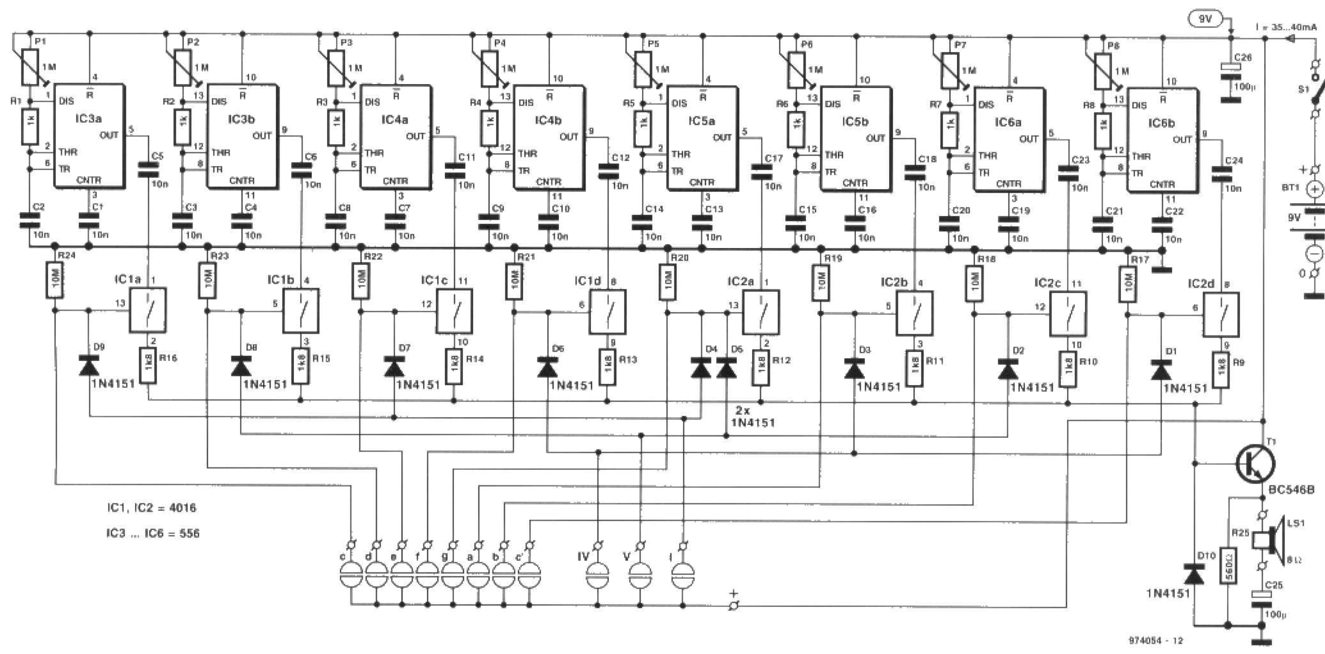
COMPONENTS LIST

Resistors:
R1-R8 = 1kΩ
R9-R16 = 1kΩ8
R17-R24 = 10MΩ
R25 = 560Ω
P1-P8 = 1MΩ preset H

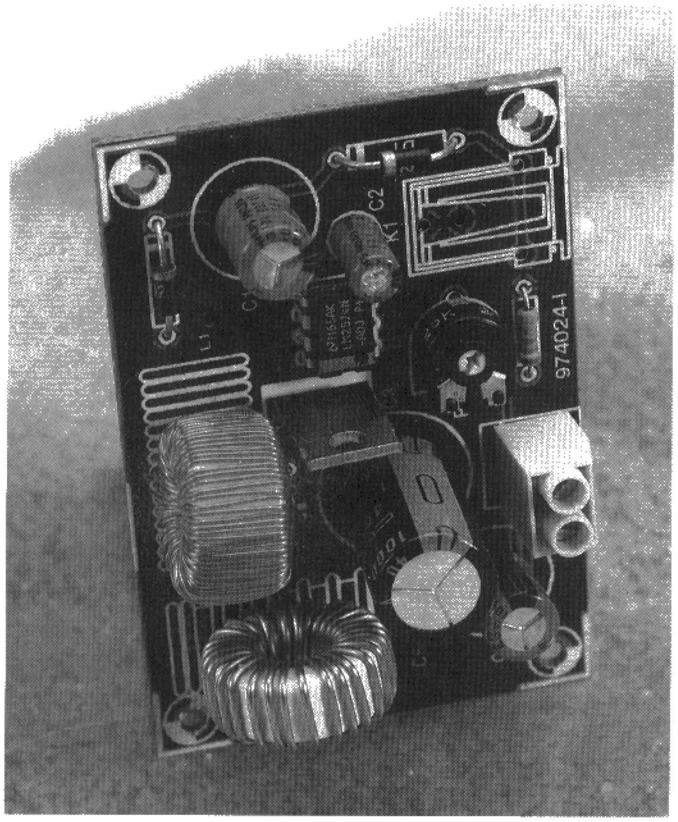
Capacitors:
C1-C24 = 10nF
C25,C26 = 100µF 16V

Semiconductors:
D1-D10 = 1N4151
T1 = BC546B
IC1,IC2 = 4016
IC3-IC6 = NE556N

Miscellaneous:
S1 = on/off switch
LS1 = miniature loudspeaker, 8Ω 0.5W



LM2574 switch-mode power supply



If you are after a small, reliable and inexpensive switch-mode power supply, National Semiconductor's LM257x series of switch-mode power supply controller ICs has several advantages over competitive products like the LT1070 (powerful but alas more expensive) and the TL497 (obsolescent). The LM257x family is second-sourced by Motorola.

The circuit shown here largely follows the NS recommended application configuration. The only critical part is inductor L1, a triac suppressor coil whose self-inductance depends on the output voltage and maximum anticipated output current. The required inductance may be found in the graph. Most triac suppressor coils have an inductance of about 100 μH. A rule of thumb says that the self-inductance is proportional with the square of the number of turns. So, a 100-μH coil may be modified into a 470-μH type by multiplying the number of turns with $\sqrt{(470/100)} \approx 2.17$. If you expect problems fitting the extra wire on the core, simply use thinner wire. Fortunately, the inductance of the coil is not particularly critical.

The PCB design will only accommodate the LM2574 0.5-A regulator which comes in an 8-pin DIP case. Solder the IC directly on to the board, as that will aid in its cooling. For the same reason, pins 6 and 8 of the regulator, though not connected internally, are soldered to the copper ground plane. The output capacity of the supply should not be pushed to the maximum (0.5 A) as the LM2574 will start to feel very uncomfortable.

The second LC circuit behind the regulator, L2-C5, is included for additional ripple suppression. If you don't mind a extra few milli-volts of ripple voltage, L2 may also be replaced by a wire link. If fitted, L2 should be a common-or-garden triac suppressor coil with a self-inductance of between 50 μH and 100 μH.

The output voltage can be set using preset P1, where

COMPONENTS LIST

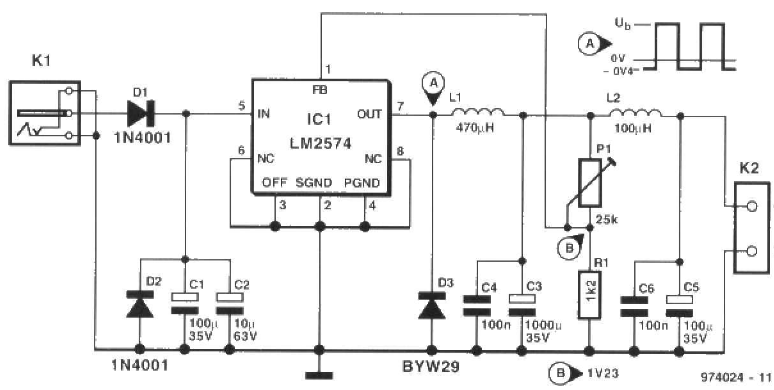
Resistors:
R1 = 1kΩ2
P1 = 25kΩ preset H

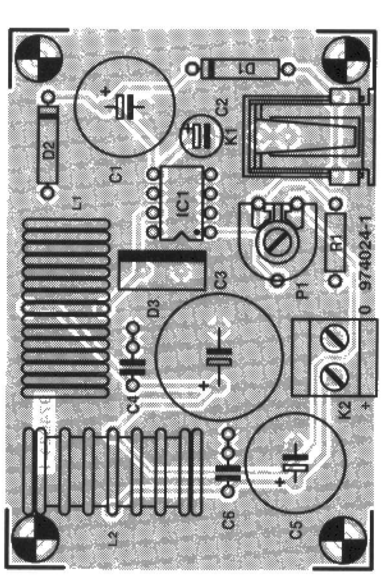
Capacitors:
C1,C5 = 100μF 35V radial
C2 = 10μF 63V radial
C3 = 1000μF 35V radial
C4,C6 = 100nF

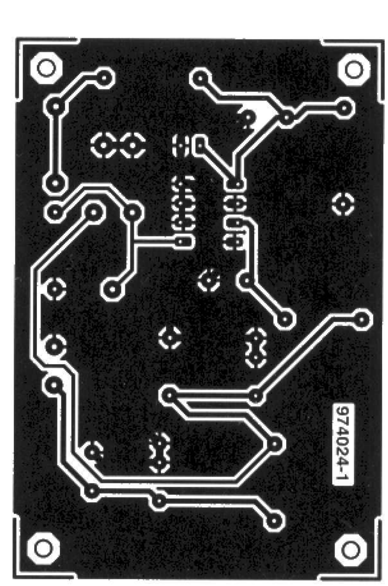
Inductors:
L1 = 470μH triac suppressor coil (see text)
L2 = 100μH triac suppressor coil

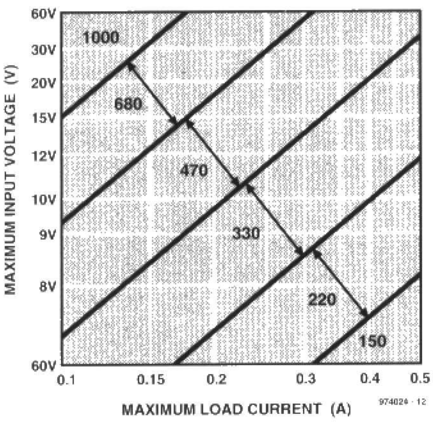
Semiconductors:
D1,D2 = 1N4001
D3 = BYW29 or similar fast Schottky diode
IC1 = LM2574N (National Semiconductor)

Miscellaneous:
K1 = mains adaptor socket, PCB mount
K2 = 2-way PCB terminal block, pitch 5mm
Printed circuit board, order code 974024 (see Readers Services page)









$$P1 = R1\,(U_0 / 1.23 - 1)$$

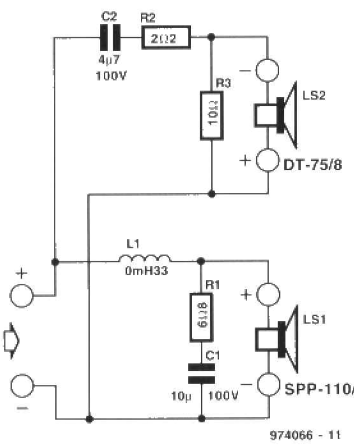
Diode D1 at the input of the circuit acts as a polarity reversal protection. If you fit D1, D2 is not required. However, if the voltage across D1 becomes too large, replace this diode by a wire link and fit D2 which will present a virtual short-circuit to a reverse input voltage.

Finally, a computer program doing all configuration calculations for these SMPSU ICs may be downloaded from http://www.national.com/design/index.html

(974024 - K. Walraven)

simple two-way loudspeaker

1



2

In this design of a simple loudspeaker enclosure an attempt has been made to achieve a reasonably good quality with a minimum of material. In spite of inexpensive drivers, this aim was met.

The cross-over filter has a 6-dB roll-off, which means only one component per driver: L_1 for the woofer and C_2 for the tweeter. There is also an impedance-correction network, R_1-C_1, for the woofer, which 'flattens' the rising impedance of this driver.

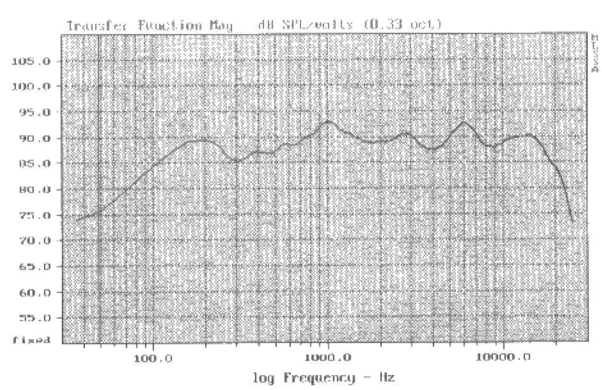
There is an attenuation network, R_2-R_3, to match the volume level of the tweeter to that of the woofer.

Note that owing to the position of the drivers, the polarization of the tweeter must be the opposite of that of the woofer.

The unit may be used as a rear speaker in a surround-sound system or with a multimedia computer. In the latter case, it must be placed well away from the monitor since the magnets of most inexpensive drivers are not screened.

The bass-reflex enclosure (**Figure 2**) has a volume of 4.5 litres. The bass-reflex port is is a standard 40 mm dia. PVC pipe, 175 mm long (if its walls are 2 mm thick; if they are 3 mm thick, the length must be 150 mm). Te material used for the enclosure is 8 mm thick chip-board or similar.

3



The nominal impedance of the system is 6 Ω. Maximum power input is 30 W. The cross-over frequency is 4 kHz. The frequency characteristic of the loudspeaker is shown in **Figure 3**.

If the coil is not obtainable ready-made, it may be wound on a non-metallic former, 28 mm dia and 28 mm long. The winding consists of seven layers of 1.5 mm dia. enamelled copper wire.

(Giesberts - 974066)

ADC for Centronics port

The conversion of analogue signals, such as the output of a temperature sensor, into a digital code remains a challenge for many computer users. The analogue-to-digital converter (ADC) shown may be of help. It uses only a few components and a simple program in BASIC. It is intended for use with PCs only.

The 8-bit converter IC is a Type TLC549 from Texas Instruments (IC_2).

A REF02 (IC_1) is used as reference source and supply regulator. It operates from 8–30 V and provides 5 V.

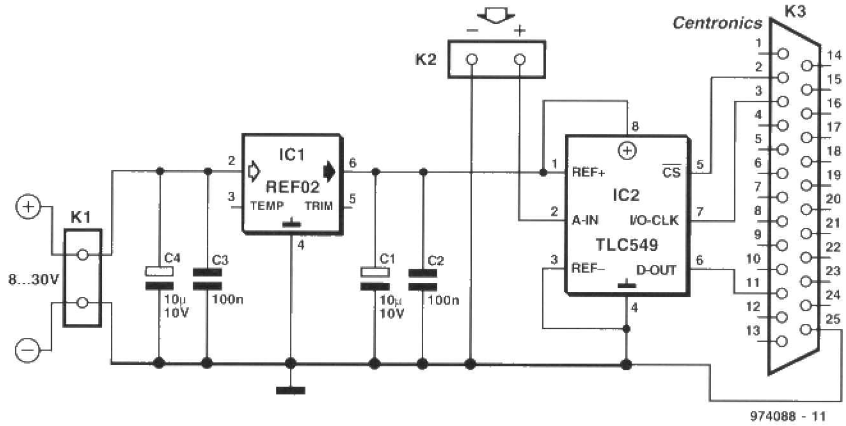
The signal to be quantized may have a level of 0–5 V and is applied to pin 2 of IC_2. A trailing edge applied to pin 5 of the IC then results in the signal being digitized. The MSB appears at pin 6.

Next, eight clock pulses are applied to the I/O-CLK input to shift all eight bits out of the converter. After the eighth clock pulse, the next cycle is started by setting a trailing edge at the /CS pin. To ensure correct conversion this line must have been high for at least 1.7 µs. If BASIC is used, this condition is normally met automatically.

The BASIC program in the box shows how this language may be used to quantize an analogue signal. Note that with a trick on line 240 the ever-present noise may be limited.

The converter draws a current of about 5 mA average.

[Anl'ingen 974088]




```
10   Base = 888:                          REM Base LPT1 (for LPT2: 632)
20   Delay = 1                            REM conversion delay time
30   Average = 10                         REM average cycles
40   CLS
50   Value = 0
60   FOR t = 1 TO Average
70   OUT (Base), 0:                       REM CS, I/O-CLK low
80   OUT (Base), 1:                       REM CS high, start conversion
90   FOR q = 1 TO Delay                   REM wait-state for conversion time
100  NEXT q
120  OUT (Base), 0:                       REM CS+CLK low
130  OUT (Base), 0:                       REM CLK high
140  OUT (Base), 0:                       REM CLK low
150  FOR i = 1 TO 7:                      REM write bit 7-0
160  x = INP (Base + 1) AND 128:          REM read and discriminate input bit
170  IF X = 128 THEN a = 0
180  IF x = 0 THEN a = 1
190  Value = Value + a * 2 ^ (7 - i)      REM constitue number
200  OUT (Base), 2:                       REM CLK high
210  OUT (Base), 0:                       REM CLK low
220  NEXT i
230  NEXT t
240  Value = Value * 5 / (255 * Average): REM mean value of "Average" numbers
                                          and conversion
250  LOCATE 10, 10:                       REM to measuring range (0-5 V)
260  PRINT USING "#.### Volt"; Value
270  GOTO 50
```

voltage-independent 2 A battery charger

Linear Technology's LT1513 is an IC that is intended for use as a 500 mA current-switch-mode controller in battery charger with constant voltage or constant current. A special property of the IC is that, depending on the input potential, it switches automatically from boost to buck mode or vice versa.

The IC may be used in chargers for Li-Ion, NiMH or NiCd batteries as long as the nominal battery voltage is ≤ 20 V. The output voltage is accurate to within 1%, which is, of course, a must in the case of Li-Ion batteries. Since the switching rate is 500 kHz and the IC is an SMD (surface-mount device), the circuit can be kept very small.

The IC contains a current-monitoring section that enables the output current of, for instance, a flyback charger to be controlled precisely. This arrangement enables the current to be monitored w.r.t. earth in isolation of the battery. This simplifies the switch-over of the batteries and prevents errors caused by earth loops.

Resistor R_3 is a current measuring device: with its value as specified, the current is 1.25 A.

The peak switching current of the IC is 3 A, which enables a charging current of up to 2 A for a single Li-Ion cell. Curves relating the peak charging current and the input voltage of the IC are shown in **Figure 2**.

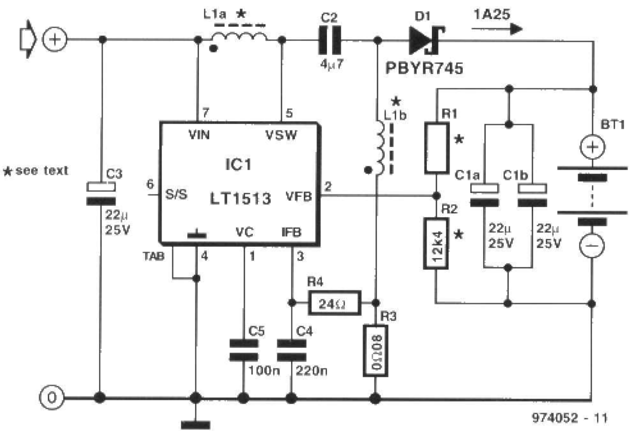
Diode D_1 should be a Schottky type.

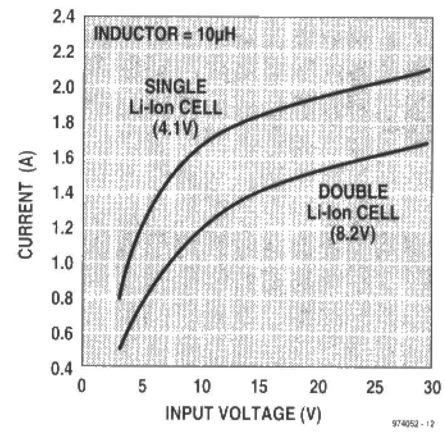
The values of resistors R_1 and R_2 must be cause a potential of 1.245 V at pin V_{FB} when the charging voltage is maximum. The current through the potential divider should be about 100 µA.

Inductors L_1 and L_2 are wound on a common core; each must have a self-inductance of about 10 µH.

Finally, capacitor C_2 must in no circumstances be an electrolytic type.

[A Linear Technology Application 974052]





blanking-level clamp

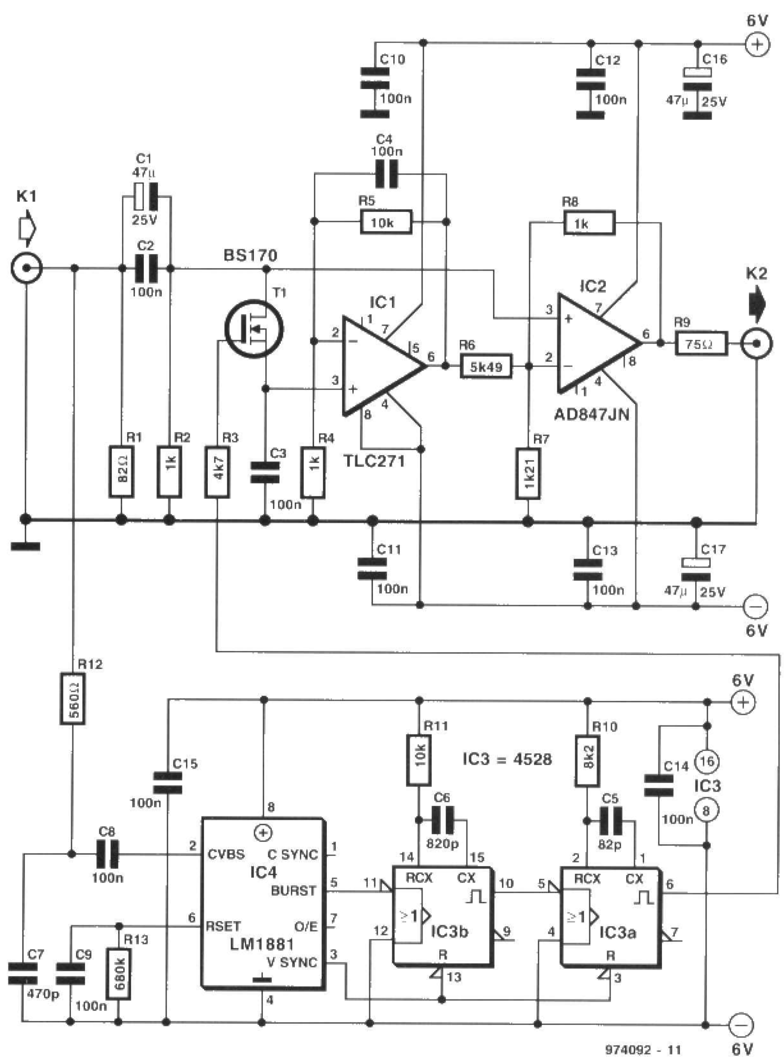
In video processing, it is desirable to hold the blanking level of the video signal at a defined voltage level. In the clamp, this is earth level. The circuit complements the video contrast expander elsewhere in this issue. The expander cannot properly handle a situation in which the sync and dark levels are dissimilar.

The clamp may also be used to advantage with a video mixer or video fader. Merely adding a potentiometer and a video switch with correct timing is sufficient to obtain the desired effects. The output signals of the sync separator used in the clamp may often prove very useful.

After it has been decoupled by C_1 and C_2, the video signal is applied to buffer/amplifier IC_2. This is an op amp with a slew rate of 300 V μs^{-1} and a unity-gain bandwidth of 50 MHz.

The voltage level between the colour burst and a given video line is sampled via T_1 and C_3. This is done at the back porch (that is, the interval immediately succeeding the sync pulse) which is normally 5.8 μs. The back porch appears at the output of IC_2 and is then at earth level.

Since the output of IC_1 forms part of the feedback loop of IC_2, it provides high amplification, which means that the value of R_6 can be fairly high. This lessens the effect on the video signal.



The normal video signal is amplified ×2, and the potential at C_3 ×−2. The amplification factor ensures the correct signal across the terminating impedance of 75 Ω.

Analysing the video signal is effected by sync separator IC_4. Since the pulse at the burst output is too wide (typically 4 μs) for the present application, IC_{3a} (which provides the control pulse for T_1) cannot be triggered at the trailing edge of the signal. The sample pulse would then arrive too late and might be taken from the video signal. Therefore, IC_{3b} is triggered at the leading edge of the burst signal (3.6 μs). The output of IC_{3b} is then used to start IC_{3a} (0.6 μs). It is then possible by giving C_5 and C_6 appropriate values to determine where the samples are taken. In the present design this is 4 μs after the frame-sync pulse.

Since the burst output of IC_4 also generates pulses during the frame synchronization, which may occur at an awkward moment and thus create

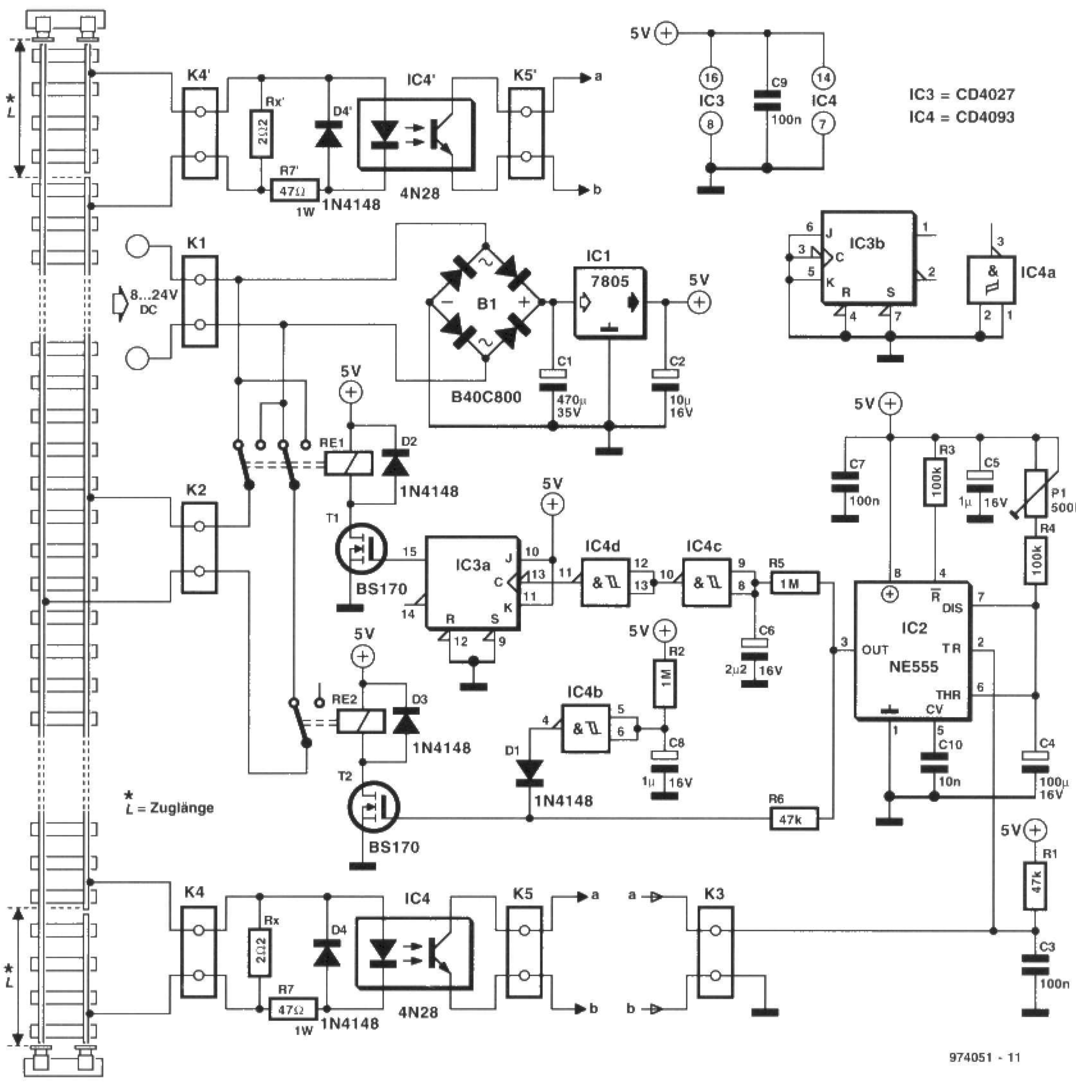
contradictory situations, sampling during the vertical synchronization is temporarily stopped by resetting IC_3 with the signal from the vertical sync output.

Resistor R_3 prevents any glitches caused by the switching of T_1 from penetrating the video signal.

The clamps draws a current of about 20 mA.

[Giesberts - 974092]

auto shuttle for model trains



The circuit is intended to make a model train shuttle continuously between two buffers. At the start and finish of each journey, one of the rails (it does not matter which) is interrupted and a resistor, R_x and R_x' is placed in series with it at the break via K_4 and K_4' respectively. The value of these resistors is shown as 2.2 Ω, but in practice they should have a value that causes a potential difference, pd, of 1.5 V across them when the break in the rail is bridged by the train(that is, the value depends on the current drawn by the locomotive).

When the break is being bridged, the relevant optoisolator, IC_4 or IC_4', is enabled. Mind the polarity: when the locomotive hits the upper buffer in the diagram, IC_4' must be enabled and when it touches the lower buffer, IC_4. Almost any type of optoisolator may be used.

The outputs of the optoisolators at K_5 and K_5' are connected in parallel and applied to the input of the relay control circuit via K_3. Since it does not matter for the operation of this control circuit which of the buffers is touched, a large number of end-stops may be connected in parallel with K_3.

The circuit operates as follows. When the supply to the train is switched on, a power-up reset is effected by the circuit based on IC_{4b} before the train can move. As soon as one of the end-stop detectors is actuated, monostable multivibrator (MMV) IC_2 is triggered, whereupon the supply to the rails is broken via T_2 and Re_2: the train stops.

After about 2 seconds (time constant R_5-C_6), bistable IC_3 is triggered, whereupon the polarity of the rail voltage is reversed. When the mono time of IC_2 (which can be set with P_1) has elapsed, relay Re_2 is re-energized and the train starts to move again, but in the opposite direction.

The relay may be a 5 V or 6 V type. The power supply for the circuit is taken from that for the train via K_1: its polarity is irrelevant. The circuit draws a current of only a few milliamperes, to which must be added the current drawn by the relay. If the supply for the train is lower than 8 V, it may be that the drop across IC_1 becomes too small. In that case, IC_1 should be replaced by a low-drop type. It is also advisable in that case to replace the bridge rectifier by four Schottky diodes Type SB130 in a bridge configuration. If, on the other hand, the supply to the train is high, it may be advisable to mount IC_1 on a suitable heat sink.

[Wolff - 974051]

STAMP security system

The Stamp Security System is suitable for the home, a small office or a shop. The heart of the system is the BASIC Stamp microcontroller. The Stamp has the advantage that it is programmed in BASIC, and requires a PC on which to write and download the program. You can suit the logic of the system to your own requirements, making it as simple or as complicated as you wish. You can trick burglars with routines of your own devising, leaving them wondering what is going to happen next, and putting them at a psychological disadvantage. You can change the program from time to time, as you think of improvements or when you expand the system.

Design by Owen Bishop

THE HARDWARE.

We use strip-board for the circuit of this project so as to allow you to put together those elements of the system that you need and to omit the rest. The circuit consists of simple input and output connections, and you will find no difficulty in adapting our suggested layout to suit your own needs.

The system is based on the premise that the best line of defence against an intruder consists of solid walls with firmly secured doors and windows. The aim is to prevent the would-be interloper from ever getting into the building. Electronically, this first line of defence consists of a peripheral loop. This is a loop of wire running around the protected area, joining switches placed at vulnerable points. The loop includes switches at every door and window by which a person might enter the home, not forgetting some of the more unlikely routes such as a hatch to the cellar or a skylight on the roof. The loop normally covers all possible entrances on the basement and ground floor and all accessible entrances on upper floors. Each entrance in the loop is protected by a normally-closed switch and the switches are connected in series. When any one door or window is opened, even by a few millimetres, the loop is broken. The control unit detects this event and sounds the alarm. If the intruder attempts to cut the wires of the loop, this too breaks the loop and triggers the alarm.

The most effective type of switch for a door or window is the magnetic reed switch. This consists of two parts. The reed switch itself is mounted on the door frame or window frame. For a wooden-framed door or window, the reed-switch may be concealed in a drilled cavity. The magnet is mounted in or on the door or window, positioned so that, when the door or window is closed, the magnet comes close to the reed switch and

makes its contacts come together. When the door is opened, the contacts spring apart, breaking the loop. If a reed switch is unsuitable for any reason it is generally possible to use a micro-switch instead.

Determined burglars may cut away parts of the window glass or smash the glass to gain access. If you think that this is a risk that must be countered, the simplest technique is to use window foil. This is adhesive metal tape stuck to the inside surface of the glass. Its ends are connected into the peripheral loop. When the glass is broken or cut, the tape is torn, and the peripheral loop is broken. A vibration detector is another and less conspicuous way to protect window glass. Most types contain a normally-closed switch which opens when vibration is detected. Vibration detectors can also be used to protect doors, cupboards, and safes. Further information on using window foil, as well as constructional details of several devices that you can build into your system, are found in the reference given at the end of this article.

The Exit Door, the door by which you leave and re-enter the house, needs special attention. From the physical point of view, there is the problem that other doors can (and should) have stout bolts on the inside, but the Exit Door can not. At least, this door must have a good quality lever lock, or possibly two locks. Latches are usually not good enough protection. **Figure 1** shows that the security system has a special loop for the Exit Door. This is to allow members of the household to come and go during the day or evening without the need to disarm the rest of the system. But the Exit Door can, if you wish, be included in the main peripheral loop. This leaves Loop 2 free for other purposes, such as a loop enclosing a different area of the house, or sensors on other buildings such as the garage and garden shed.

You may decide not to fit a switch to the Exit Door but to rely on burglar-proof locks and perhaps the fact that the door is in an exposed position under the surveillance of passers-by. If you do fit a switch there is the problem of leaving the house when all loops are armed, without triggering the siren. Our program provides a delay to allow you to do this. Just before you leave the house, you press a button on the control panel. You then have 30 seconds to leave the house and shut the Exit Door before the system resumes its activity. If this is not long enough, you can set the program to wait longer. When you return to the house you have 10 seconds (or longer, if you need it) to go to the control panel and press the button again or insert the security key (see later) into its socket. The alarm is sounded if you do not do this in time. An intruder breaking in through the Exit Door will probably be unaware of the need to press the button. Even if the intruder thinks of such a possibility, the control panel is hidden away (perhaps in a cupboard upstairs) and is unlikely to be found within 10 seconds.

If you are a pessimist, or if a perimeter loop is impractical in your home, you may have a second line of defence. This does not necessarily prevent the intruder from entering the area, but gives warning as soon as his or her presence there is detected. Devices used for this purpose may include ready-made units such as infra-red beam detectors, microwave or ultrasonic motion detectors and passive infra-red (PIR) detectors. A number of such devices are described in the reference. These devices usually have a pair of normally-closed contacts which may be wired into the peripheral loop, or into a separate loop (loop 3, Figure 1). Most of them operate on 8 V to 16 V DC so can be supplied from the same power supply as the Stamp system. Another second-line device is a pressure-mat. This is concealed beneath the carpet and located where an intruder is likely to stand on it. Typical places are just inside a door, in a corridor, or in front of a safe or valuable object. Pressure mats are normally open-circuit and close when stood on. This means that they need separate connections to the control unit. Figure 1 shows mats and other normally-open switches (loop 4) wired in parallel for this reason. Take care to conceal the wiring because mats and normally-open switches can be inactivated by cutting the wires.

As well as the more conventional security devices we have mentioned above, there is plenty of scope in this system for you to pit your wits against the prospective intruder. For example, TV sets are a favourite of the small-time burglar, so booby-trap the set with a microswitch hidden beneath or behind it. When the set is lifted or moved, the armature of the switch is released and the contacts open. Tamper-proofing is another important aspect of security. You could include in series with your main peripheral loop (Figure 7) a micro-switch located inside the case of the control unit. When the lid or panel is in position it presses against the armature of the switch, holding the contacts closed. As soon as the lid is loosened by someone trying to unscrew its fastenings, pressure is released and the alarm is sounded. We must not forget other forms of security. Smoke and fire alarms, flood alarms, gas alarms and other sensors can all be included in the system if

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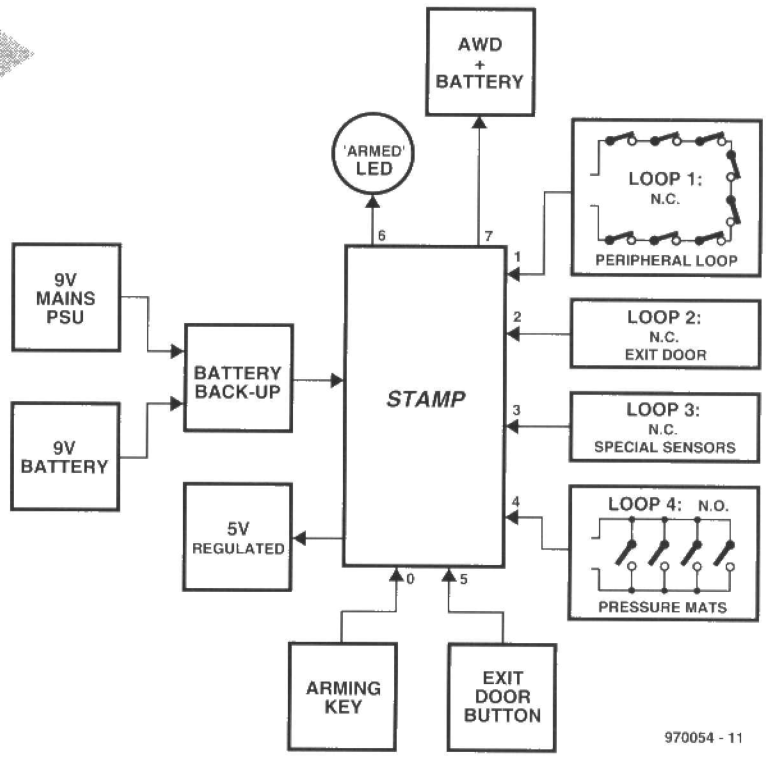

Figure 1. The basic Stamp Security System.

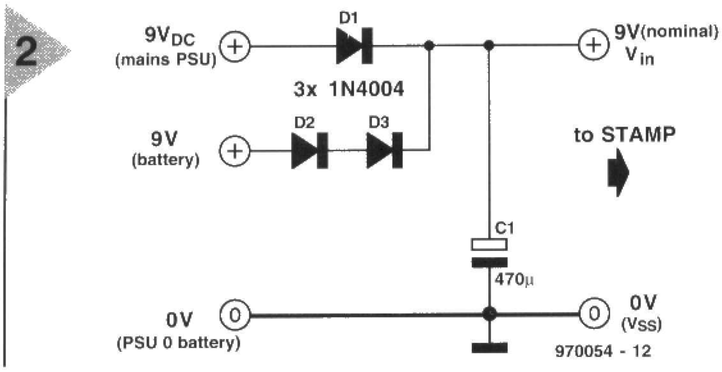

Figure 2. Battery back-up circuit.

they have a switched output. An-other useful alarm is a panic button to be pressed in cases of physical attack. Or it might be useful beside the bed of an invalid or an elderly person. Per-haps in this last application we might program the Stamp to sound a more melodious buzzer instead of the usual ear-splitting siren.

The system provides up to four sensor loops and the way each is used is optional. In the constructional details given later, three of these are used for normally-closed switches wired in series. It is suggested in Figure 1 that the first of the loops is used for the main peripheral loop and the second for the Exit Door, which we may not want to activate during the day except when we leave the house. The third loop can be used for panic buttons, smoke detectors and other devices which need to be active day and night. The fourth loop could cover devices with normally-open switches, such as pressure-mats.

OTHER INPUTS

The arm/disarm input accepts a security key available only to the operator of the system. This is a coaxial plug containing a resistor of a particular value. The system is disarmed by inserting the plug. The Stamp reads the value of the resistor and, if this is correct, disarms the system, allowing you to reset the loop switches, to test the loops, or to open the control box to re-program the Stamp without triggering the alarm. Withdrawing the plug arms the system and it subsequently sounds the alarm whenever a door or window is opened, fire is detected or anything else untoward happens, including attempts to switch off the loops. The intruder can not disarm the system by switching off the mains power supply because it has a back-up battery inside the control case.

The other input is the Exit Button. Pressing this before you leave home allows you to open the Exit Door (or any other door or window) during the next 30 seconds without triggering the alarm. On returning home you have to press this button or disarm the system within 10 seconds of opening the door.

OUTPUTS

The control box has a flashing LED to indicate when the Stamp has been armed. This is controlled directly by the Stamp's program so, if this is flashing, you know that the Stamp is on the alert. If the system is subsequently disarmed, or its action is suspended as you leave the house, the LED goes out. The other output is the siren switch. The siren can be switched through a MOSFET wired directly to the Stamp. If you adopt this simple expedient, you will need to take special care to conceal the wiring between the control box and the siren. Otherwise the trespasser may cut the wire and prevent the siren from sounding. However, we describe a circuit to eliminate this, by providing the siren with an independent power supply. Then the effect of cutting the connecting wire is to turn the siren on!

CIRCUIT DETAILS

The circuit operates on 9 V DC which can be provided either by a 9 V plug-in mains adapter, a 9 V battery (6 AA cells in a battery box), or by the mains PSU backed up by the battery. The back-up system is recommended (**Figure 2**) and there is room for this on the Stamp's motherboard. When power comes from the mains PSU the output voltage is one diode drop below 9 V, about 8.3 V. The battery supply has two diode drops; this is necessary to prevent current being drawn from the battery when the mains PSU is on. If this goes off, current flows from the battery. The output voltage falls to about 7.6 V but this is still sufficient to drive the Stamp.

The +5 V regulated supply from the Stamp is unaffected by which supply is in use. With the back-up in operation there is no way of disconnecting power to the system except by opening the control box and removing the battery-clip from the battery. Even then, if power is successfully turned off, the siren will start to sound, using its independent supply (**Figure 3b**).

The principle of the siren circuit is that it is actively held in the 'off' state by short-circuiting the gate and source of the MOSFET. The short-circuit route is provided by a transistor in an opto coupler. As long as the Stamp provides current to the LED in the coupler, the transistor passes current which short-circuits the gate and

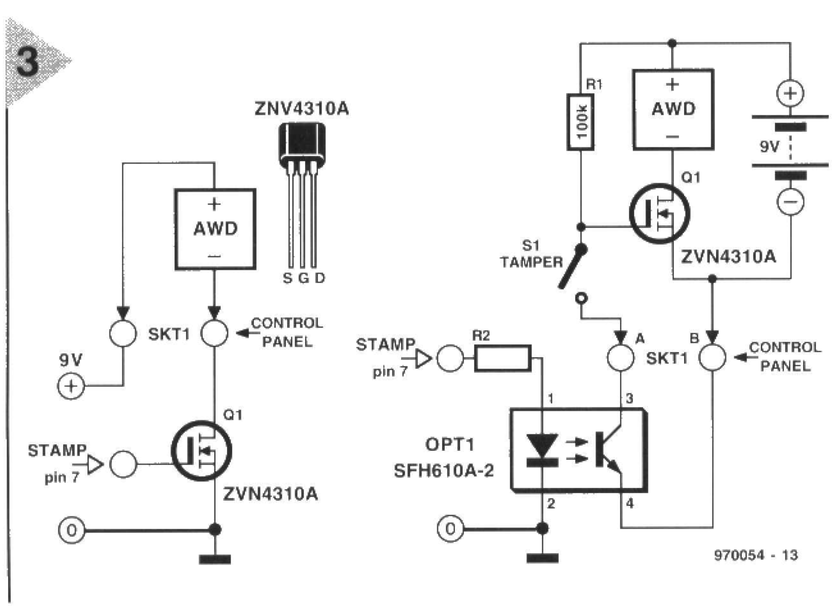

Figure 3. Circuits for switching the AWD (siren): (a) direct; (b) with independent battery.

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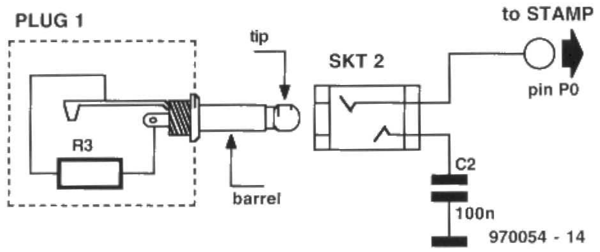

Figure 4. Arming plug circuit.

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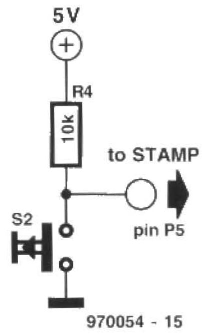

Figure 5. Exit button.

Figure 6. 'Armed' flashing indicator.

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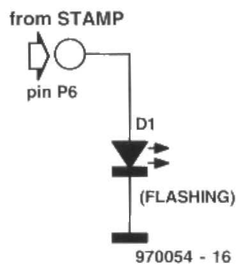

source. In the alarm condition, the Stamp output goes low, turning off the LED. The transistor no longer conducts, gate voltage is pulled up by R_1, the MOSFET is turned on and the siren or other audible warning device (AWD) sounds. We use a ready-made unit for the AWD because robust and very loud (100 dB or more) sirens and sounders are available at relatively low cost. Part of the system is powered from the 5 V supply from the Stamp's own regulator.

The arm/disarm circuit (**Figure 4**) makes use of the Stamp's ability to measure the time taken to charge a capacitor. The value of the resistor may be between 5 kΩ and 50 kΩ and you program the Stamp to accept only one particular value of resistor. The Exit button circuit (**Figure 5**) has a push-button, S_2, either mounted on the control panel or hidden away in an inconspicuous place. The input to pin 5 of the Stamp is held at logic high (+5 V) except when the button is pressed.

The loop interface circuits are on the main board, mounted just behind the control box panel so that the LEDs and the switches are accessible through holes cut in the panel. The 'armed' LED is also on this board and, since this is the type with a built-in flashing circuit and able to operate on a 5 V supply, it is connected directly to the output pin, pin 6 (**Figure 6**). The loop interface circuits are identical (**Figure 7**), since the Stamp can be programmed to accept either a normally-low or a normally-high input. Each loop is operative (the loop is brought into the system) when the IN/OUT switch (S_3–S_6) is in position 1. If the loop has normally-closed switches there is a short-circuit between A and B and the voltage at the pin is held at zero, as long as all switches are closed. When any switch is opened, the pull-up resistor (R_5–R_8) brings the pin voltage up to 5 V (logic high). This event is detected by the program and the alarm is sounded. The loop is switched out of action by putting the IN/OUT switch in position 2. The Stamp is then connected to 0V through R_9–R_{12} and C_3–C_6, so that we have the same situation as in Figure 4. The Stamp is programmed to test each input pin before the system is armed, to register which loops are turned on and which are turned off. It repeats this interrogation frequently and, if the switches are changed while the system is armed, it turns on the siren as a warning that the system is being tampered with. The output level of the loop is indicated by a row of four LEDs (LED_2–LED_5) which are switched on or off by four MOSFET transistors (Q_4–Q_7). With a normally-closed loop the low output turns off the MOSFET and the LED goes out. This feature is useful for testing the loop, and operates with the IN/OUT switch in either position. Before arming the system it is wise to check that all relevant LEDs are out. If any are on, it may indicate that a door or window has been left open accidentally.

If the circuit is connected to a loop of normally-open switches (in parallel) it operates in the reverse sense. The output level is normally high and the LED is on. This is what we expect to find when checking the system before arming it. If any one of the switches is closed, the output falls to 0 V and the LED goes out.

CONSTRUCTION

Although the prototype was constructed on strip board, a printed-circuit board (not available ready-made) was designed for the convenience of many readers—see **Figure 8**. In the design, it is assumed that you use battery back-up. If you do not, D_1–D_3 must be omitted. Notwithstanding the PCB, the description in this section is based on the strip board.

If you switch the siren directly, the opto coupler, OPT_1, is not required.

The board allows you to install up

Figure 7. Loop interface circuit. Up to four of these are allowed.

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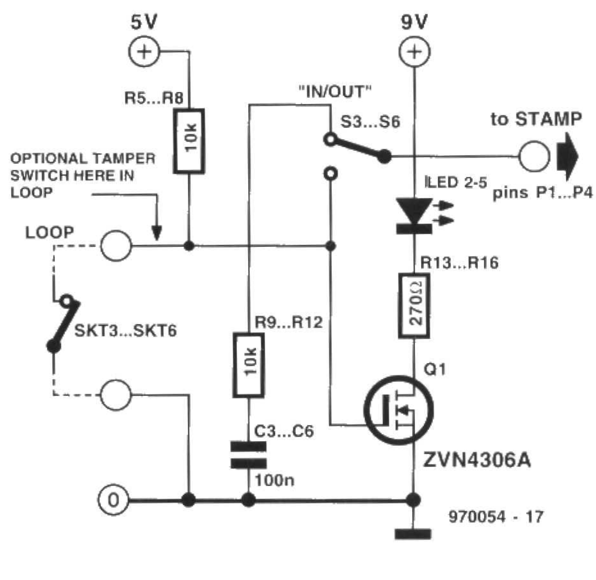

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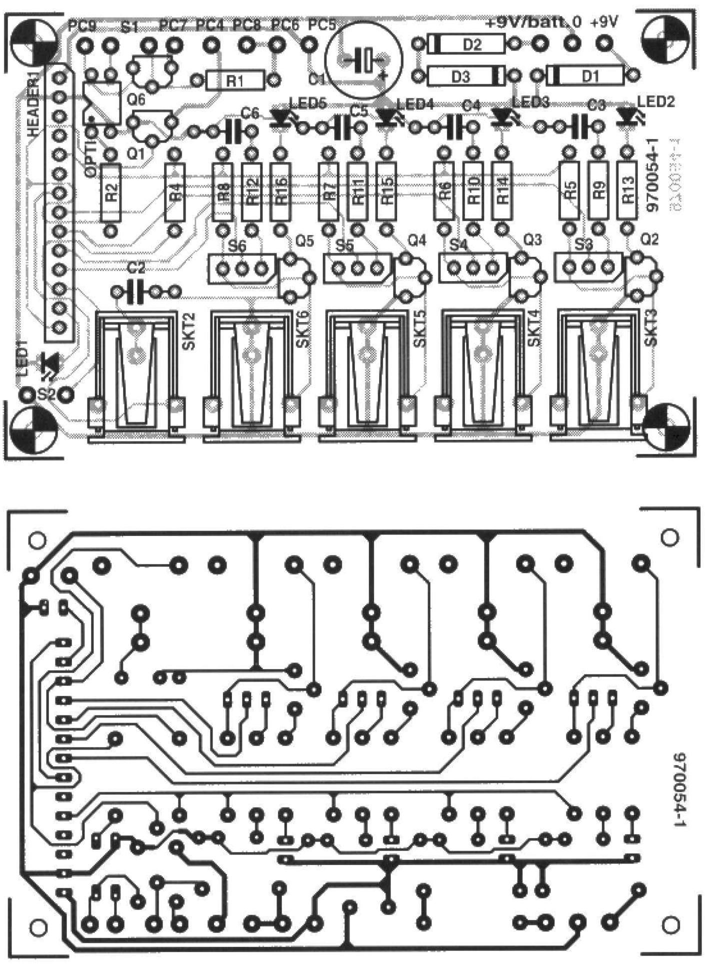


Figure 8. Although the prototype was constructed on strip board, a printed-circuit board (not available ready-made) was designed for the convenience of many readers. In the design, it is assumed that you use battery back-up. If you do not, D_1–D_3 must be omitted. Notwithstanding the PCB, the description in this section is based on the strip board.

to four normally-closed or normally-open loop.

It is important not to confuse the connections to the +9 V supply with those to the regulated +5 V output from the Stamp.

To avoid risk of accidental damage, remove the Stamp from its socket before working on the board; keep it in conductive foam or in the conductive packet in which it was purchased.

Mounting points are connected horizontally to the pins of the header and the in-line socket for the Stamp. The remainder of the points on the board are isolated, so connections must be provided above or beneath the board.

Longer connections are provided by wires running on the component side of the board. Often the ends of these wires can be left long, passed through a hole then bent to lie close the under surface and carried along beneath the board to solder to adjacent points.

Points to be connected under the board (not shown in Figure 8) are: A_1–A_3, D_6–D_7, D_6–E_6, C_{11}–D_{11}, C_{15}–C_{16}, F_{15}–F_{16}, G_8–G_{10}, G_8–H_8, L_8–L_9, M_8–M_9, L_{12}–L_{16} and M_{12}–M_{14}.

We have provided an 8-pin d.i.l. socket to the opto coupler. This allows room for a 6-pin or 8-pin opto coupler, if required.

The siren circuit is very small so that it can be located inside the case of the siren. The siren may be mounted on the outside of the house in a purpose-made weatherproof enclosure. All wiring to the enclosure should be concealed. Often the wiring comes from a loft through a hole drilled in the brickwork, which emerges behind the enclosure. Many designs of siren enclosure include a tamper-proof switch. This switch is held closed when the cover of the enclosure is in place. If any attempt is made to unscrew the cover, the switch springs open. This happens before the cover can actually be removed. If fitted, this switch is wired in series with SKT_1, as in Figure 3.

The layout may be varied to suit individual systems. Possibly you may install only 1 or 2 loops to begin with, so some of the components may be omitted. The switch is a 4-pole cross-over switch, of which each switch consists of two switches operating in the opposite sense. To obtain cross-over action the pins on the right are soldered together in pairs. The switches are pushed to the right to bring a loop into the system and to the left to take it out. Other switching methods are possible. For instance, you could have four toggle switches mounted on the front panel of the

components list

Resistors:
(0.25 W, tolerance 5% or better)
R1 = 100 kΩ
R2 and R13 to R16 = 270 Ω
R3 = 5 kΩ to 50 kΩ (optional)
R4 to R12 = 10 kΩ

Capacitors:
C1 = 470 μF, electrolytic
C2 to C6 = 100 nF polyester

Semiconductors:
D1 to D3 = 1N4004
LED1 = flashing LED
LED2 to LED5 = LED rectangular
OPT1 = SFH610A opto coupler (or similar)
Q1 to Q5 = ZVN4310A MOSFET

Miscellaneous :
S1 microswitch (optional, may be provided with siren enclosure), optionally a second microswitch for tamper-proofing the control box
S2 push-to-make push-button, panelmounting
S3 to S6 = pcb mounting 4-pole dil crossover switch (RS stock no: 337-548)
SKT1 and SKT3 to SKT6 = 3.5 mm jack sockets, mono
SKT2 = 2.5 mm jack socket, panel-mounting, mono
Plugs to fit above sockets
2.1 mm DC plug and socket for supply from mains PSU
BASIC Stamp BS-1, with motherboard
10-way and 2- (or 3-) way sockets to fit header of mother board. Stripboard for siren board 22 × 20 mm (8 strips, 7 holes)
Stripboard for main board 87 × 83 mm (34 strips, 32 holes); 1 mm terminal pins (18 off)
8-pin dil IC socket
Reed-switch and magnet, surface-mounting or flush mounting, for each door and window
Other miscellaneous sensors as described in the text
Enclosure, approx 50 × 90 × 150 mm. Bolts, nuts, washers, for mounting boards
Siren or audible warning device, to operate on 9 V DC
Siren enclosure (optional).

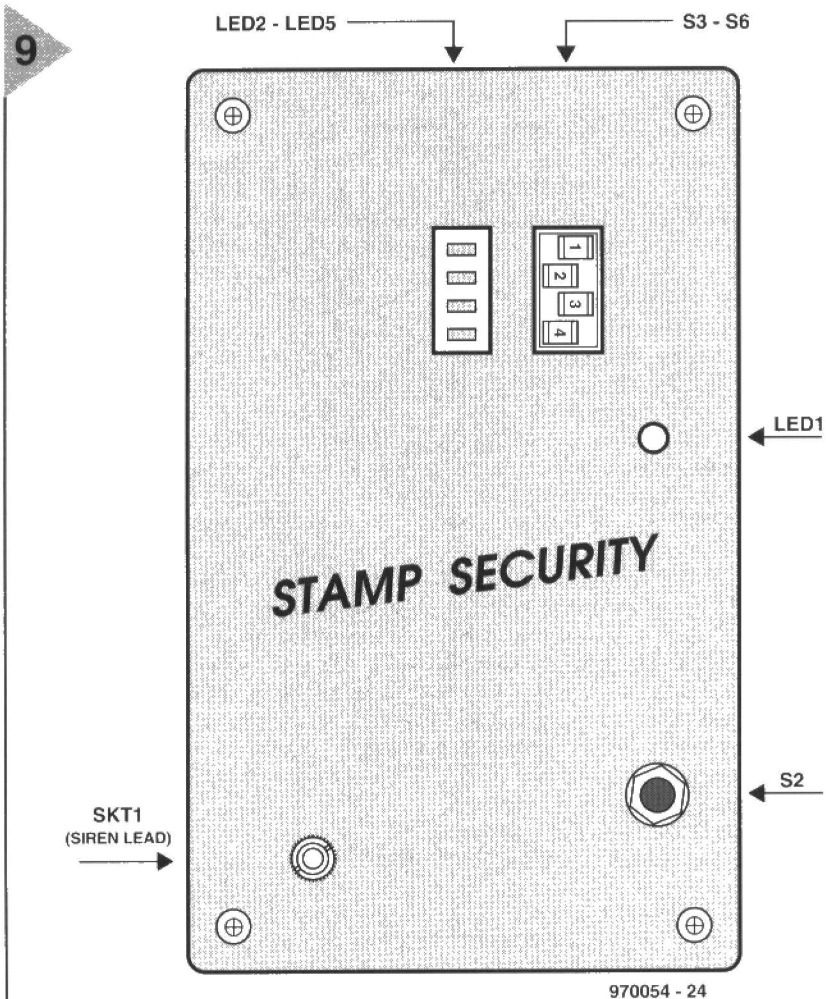


Figure 9. Suggested front panel for the control box (not available ready-made).

enclosure, with leads going to the appropriate positions on the board. Connection to the loops is by 3.5 mm jack sockets and plugs (mono). The sockets are arranged in a row along the bottom edge of the board. With the type of socket we used, one of the terminals projects vertically downward and ends in a tag for soldering. We cut off the wider end of the tag, then squeezed the remainder of the tag with pliers to make it narrow enough to pass through a slightly enlarged hole in strip JJ. Before soldering the socket in position we coated the lower surface of its body with adhesive, to fix it to the board. This arrangement means that the connections to the loops are inside the control box, and it is necessary to open the box to disconnect the loops. We prefer this to having the sockets accessible on the front panel of the box.

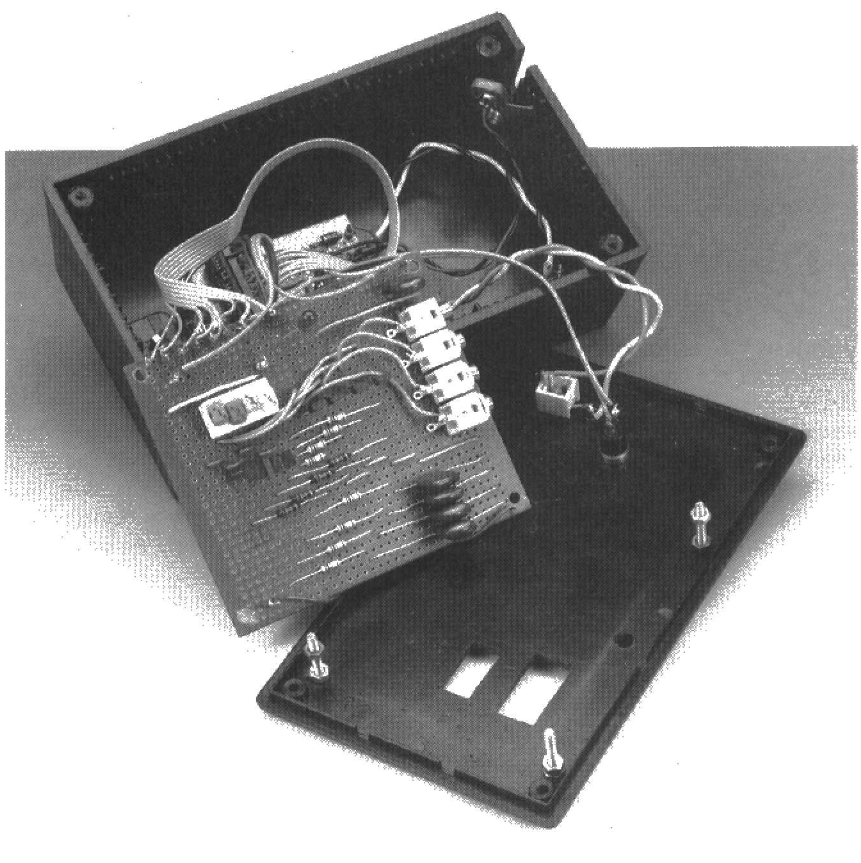
A useful accessory is a 3.5 mm mono jack plug with its terminals wired together, or possibly 2 or 3 such plugs, to make a shorting plug. A shorting plug is inserted into any of sockets 3–6 to act as a closed loop. This is useful when debugging and testing the system. It is also useful if you provide sockets for loops that have not yet been implemented.

Control box

In general, this should be as small and inconspicuous as possible and preferably installed inside a cupboard, perhaps locked. To give nothing away to the intruder, controls and indicators are not labelled. The Stamp mother board and the 9 V battery holder are bolted to the floor of the box. The main board is supported on four bolts behind the front panel. A slit cut vertically in one side of the box allows cables to pass in for connections to the main board. These comprise the (up to) four loops and the siren connection. You may also decide to mount the Exit Button externally. A suggested front panel is shown in **Figure 9**.

Disarming key

This consists of a 2.5 mm jack plug with a resistor soldered between the terminal tags. The resistor may have any value in the range 5 kΩ to 50 kΩ. If you intend to make a duplicate key, use 1% tolerance resistors of the same value in both keys, as the Stamp is able to measure resistance fairly pre-



cisely. It is possible to have keys of two different values. Then the Stamp can be programmed to recognise each key individually and to respond differently according to which key is inserted. For example when an 'overnight' key is inserted and then withdrawn, the Stamp is programmed not to allow the switching of the loops to be changed for, say, 10 hours. We have suggested the smallest size of jack plug, so that it has a small socket which can be located inconspicuously on the lower side or rear of the control panel. Intruders may never discover the socket and will not guess what it is for. If you prefer a less mislayable key, use a 6.5 mm jack plug and socket.

THE SOFTWARE

There is no one way to program the Stamp to control the security system. Much depends on how much of the system has been implemented in hardware and even more depends on just how you want it to operate. Below we suggest one program with remarks that will help you adapt it in various ways. First we describe some short programs for testing the system, to make sure that the circuit connected to each input/output pin is working properly.

TESTING

Connect the Stamp to your PC, using the lead supplied with the Stamp development kit. Switch on the power supply to the system; it is best to have the siren disconnected at this stage. Run 'stamp.exe', which is a program running under DOS and will normally be in a separate directory which, for convenience, may also be called 'STAMP'. We will test each of the pins and its connected circuit by a series of programs listed below. You may like to type these in and save them before running the tests.

Test 0

This tests pin p0, the one that detects whether or not the correct disarming key is inserted in its socket. As well as testing the circuit, we are finding out the value by which Stamp will recognise the correct key. This involves making Stamp measure a value related to the resistance of the resistor in the key. It does this by measuring the time taken to charge the series capacitor up to a given level. We use the 'pot' command which has the syntax:

```
pot pin, scale, variable
```

'Pin' in this case is pin 0 and we will begin with an arbitrary 'scale' value of 128, which is midway in the permitted range of 0 to 255. 'Variable' is the name of a location in which the result of the test is to be stored. The program is:

```
'Test0
pot 0, 128, b1
debug b1
end
```

The 'debug' command is applicable only to programs being developed or tested on the computer. It causes a special panel to be displayed on the screen on which the value of b1 is displayed. Plug the key into its socket and run the program. The aim is to get b1 to have a value of around 128. If the value of b1 is much less than 128 increase the scale value and run the program again. Conversely, if b1 is much more than 128, decrease the scale value. When you are satisfied that the value is close enough to 128, make a note of the scale value and the value of b1 obtained. Check values by removing the plug and reinserting it several times, testing each time to confirm that the circuit is working reliably. The values of b1 should all come to within one or two units of each other.

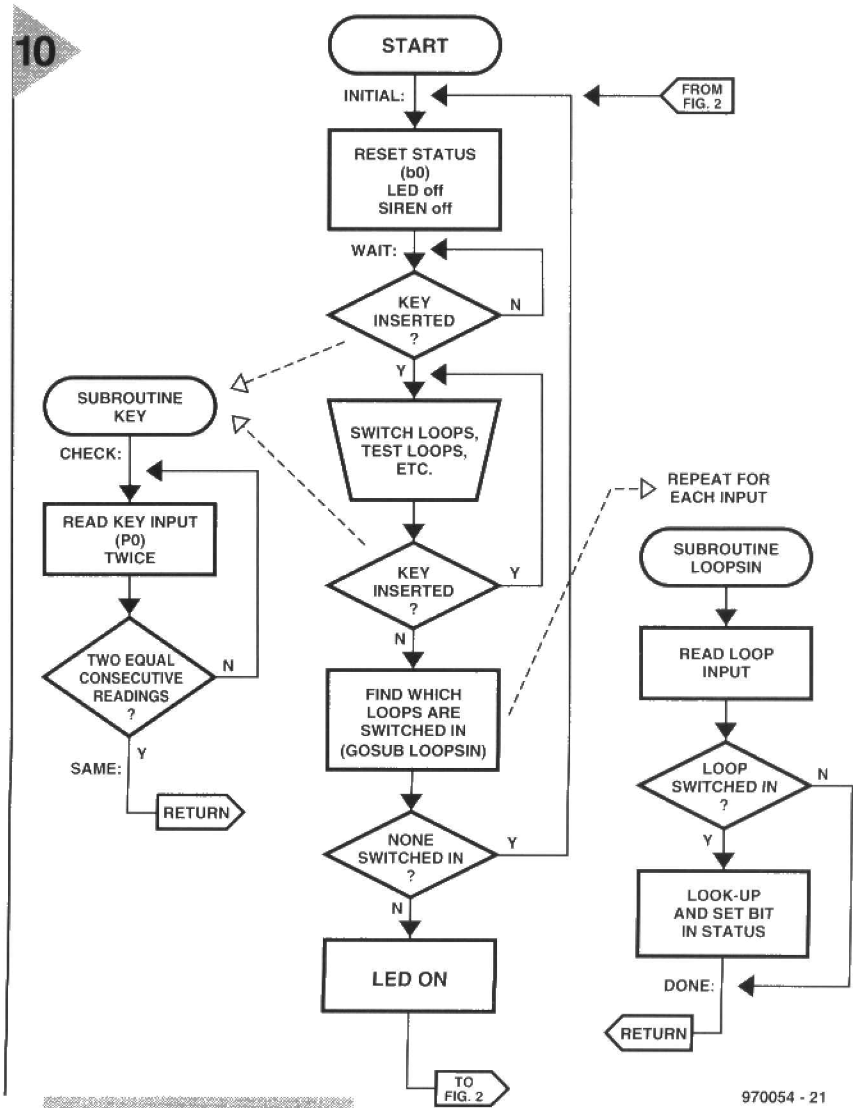


Figure 10. Flow chart of preliminary stages of Secure 1.

Test 1–4

These test the pins which monitor the loops. The program for pin 1 is given below and programs for pins 2, 3 and 4 are obtained by altering pin numbers in the 'pot' and b2 = pin1 lines:

```
' Test1to4
pot 1, 60, b1
debug b1
dirs = %110000
b2 = pin1
debug b2
```

For these tests the power is switched on and the peripheral or other loop plugged into its socket. Slide the selector switch for loop 1 to the left to take the loop out of circuit. Run the program. As above, the initial aim is to get b1 returned with a value close to 128. Raise or lower the scale value as before, then make a note of the scale value and the corresponding b1.

The fact that b1 has a value greater than zero means that the pin is connected to the resistor/capacitor combination. This tells the Stamp that the loop is switched out of the system. In all tests of this program so far, we find b2 = 0, because the pin is at 0 V.

Next, slide the switch to the right; plug in the normally-closed loop. The LED is off. Running the program gives b1 = 0 and b2 = 0. The value of b1 indicates that the pin is no longer connected to the resistor/capacitor combination. This tells the Stamp that the loop has been switched into the system, but may be open or closed. Run the program with the loop closed and obtain b1 = 0 and b2 = 0. Run again with the loop open to obtain b1 = 0 and b2 = 1. The value 1 indicates a high logic level of +5 V.

The same test applies to loop 4 or any other loop of normally-open switches. We take account of the different action of the loops in the security programming, in which the alarm condition for normally closed loops is 1, while that for normally-open loops is 0.

Test 5

Check the Exit Button by running this program twice, once with the button not pressed and again with the button pressed:

```
'Test5
dirs = %11000000
b1 = pin5
debug b1
end
```

With the button not pressed, b1 = 1. With the button pressed, b1 = 0.

Test 6 & 7

The two outputs are tested with the same program:

```
'Test6&7
high 6
pause 1000
low 6
end
```

This turns on the flashing LED for 10 seconds. To test the siren, when p7 is connected directly to the switching MOSFET as in Figure 3a, amend the number '6' to '7'. The siren sounds for 10 seconds when the program is run. For a siren with its own battery, and controlled through an opto coupler (Figure 3b), amend 'high 6' to 'low 7' and 'low 6' to 'high 7'.

CONTROL PROGRAM

Figure 10 is a flow chart of the first stages of the program, in which we assume that loops 1 to 3 are to be normally-closed, loop 4 is normally-open, and the siren is turned on by a low (0) output. The state of the circuit is held in an 8-bit status register, for which we use the byte named b0, which is bit-addressable. The settings of the bits are shown in the table.

Bits 0 and 5 to 7 are not used in our program but are available for you to use. For example you might need to register if the system is armed or not by setting bit 0 equal to 1 on arming and resetting it to 0 on disarming. The information stored in this bit could be used later in the program to select a particular action. Or you might use another bit which is set to 1 when the smoke-detector is triggered. In the siren-sounding routine, the state of this bit could determine which of two sirens is sounded, or whether the siren is sounded continuously or intermittently. In this way the household would know if the alarm was the result of intrusion or of fire.

The program begins when power is switched on and the Stamp is automatically reset. It returns to this state whenever the power supply is interrupted. The Initial stage clears the status register, sets the pins as outputs or inputs and, just to make sure, sets p6 low (LED not flashing) and p7 high (siren not sounding, but remember to use 'low p7' if you are switching the siren directly). This is followed by a Wait stage during which the program continually monitors the key socket to detect if the key is inserted.

When the key is inserted, the program runs on to the Setup stage, during which the operator switches loops into or out of the system. The rhomboidal shape in the flowchart indicates that this is a manual operation. The loops may be switched in or out any number of times until the correct combination is attained. This stage also allows the loops themselves to be checked, using the loop LEDs to indicate if the correct low or high loop output is obtained. When all loops are set as required, the key is removed, and put in a secure place.

Removing the key lets the program continue to the next stage. For each of pins 1–4 in turn, the program goes to subroutine 'loopsin' and uses the 'pot' command to find out if the loop switch is set to the loop output (position 1) or to the resistor/capacitor (position 2). This tells the Stamp whether the loop is switched in or out and the corresponding bits in the status register are set accordingly. Changes made to the switches later without the key being present will not be registered, so this feature guards against unauthorised changing of the loop settings. If 'loopsin' finds that all loops have been switched out, the system is evidently

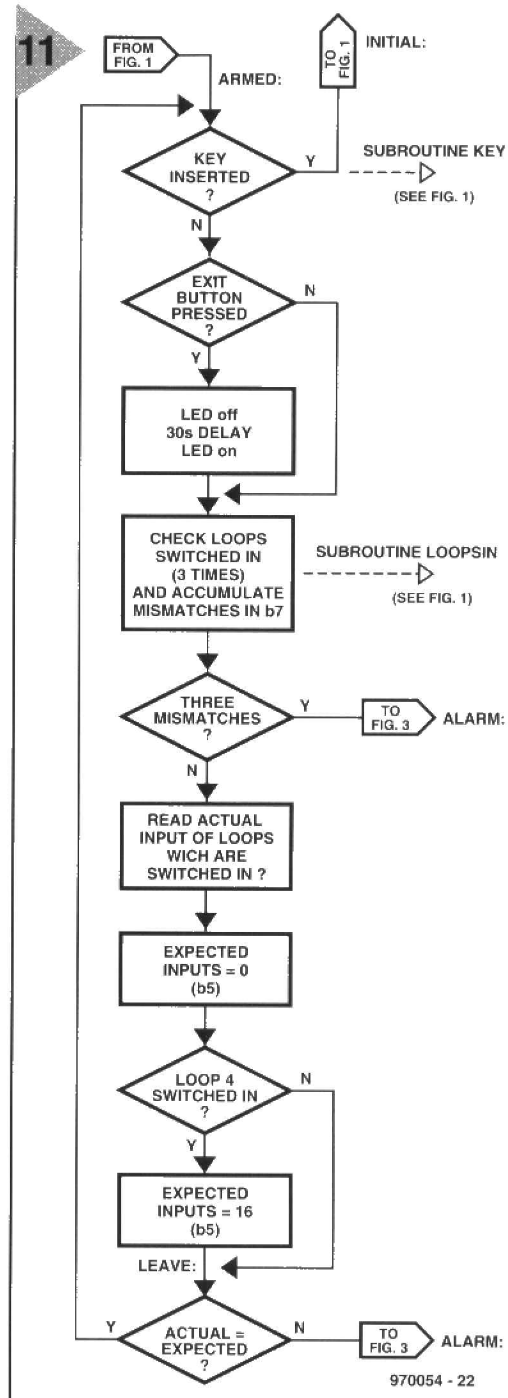


Figure 11. Flow chart of main program loop.

not to be armed and the program returns to the Initial stage. It waits there indefinitely until the operator re-inserts the key and switches on one or more loops. If one or more loops are found to be switched on at the end of this stage, the program proceeds to the Armed stage and the LED begins to flash.

The Armed stage (**Figure 11**) consists of a multi-stage program loop around which the Stamp cycles indefinitely. The operator may now let the control unit take over the care of the premises. The first task in the Armed loop is to check if the key is inserted, in which case the program jumps

12

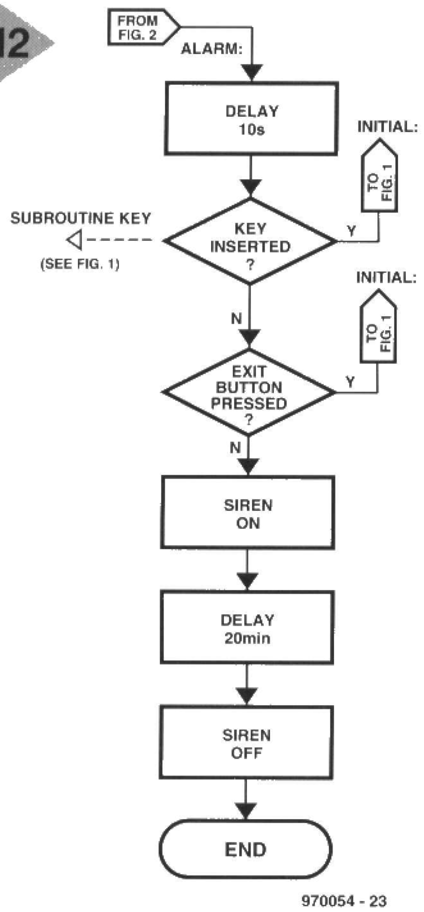


Figure 12. Flow chart of siren sounding routine.

back to the Select stage, where the LED is switched off and the status register is cleared ready for the loop switches to be reset. Otherwise the Stamp continues to the next stage in the Armed loop which is to monitor the Exit button. If this is pressed, indicating that someone wants to leave the house (or maybe someone already inside the house wants to admit someone), the program enters a 30 seconds delay phase. The flashing LED is switched off during this phase, showing that it is safe to open the door.

The next stage is to interrogate the loops to see if their settings have been changed since they were first set. The original settings are in b0 and are now copied to b5. This is done simply by making b5 equal to b0. If any of the other bits in the status register are in use, substitute 'b5 = b0 & 30" using the AND operator to pick out the required bits. Now the current settings are read into b0, using 'loopsin'. On return from 'loopsin', the alarm is sounds if the new value of b0 is not equal to b5, the old value. However, to guard against small errors that sometimes arise with the 'pot' command, the process is repeated 3 times and the alarm sounds only if a difference is discovered on every repeat. If the alarm is not sounded, the next line restores b0 to its original state.

Finally, the state of the loops is read and compared with what is expected in the absence of an intruder. This routine includes only those loops which have been switched into the system. If the unexpected is found, it indicates an intruder (or maybe someone has unthinkingly opened a window!) and the siren sounds. With the 4-loop system set up as we have suggested, we expect to find loop 4 high and the others low. This is equivalent to a value of 16 in b4. If one or more of loops are 1 to 3 are excluded, they will return a zero value, so the expected value is still 16. If loop 4 is excluded, it returns zero and the expected value is zero for all.

Figure 12 shows the alarm sequence. First there is a 10-second delay. This allows time for a person to enter by the Exit Door and reach to the control box, either pressing

PROGRAMS

The test programs are:

```
'Test 0
pot 0,135,b1
debug b1
end

'Test 1 to 4
pot 1,60,b1
debug b1
dirs = %11000000
b2 = pin1
debug b2
end

'Test5
dirs = %1100000
b1= pin5
debug b1
end

'Test6or7
high 6
pause 10000
low 6
end
```

It may be necessary to edit pin numbers to adapt the program to a particular pin.

The control program is:

```
'Secure1
initial:
dirs=%00111111
b0=0:low 6:high 7
wait:
gosub key:if b1<128 OR b1>133 then wait          ❶
pause 500

setup:
gosub key:if b1>128 AND b1<133 then setup
1 gosub loopsin
if b0=0 then initial
b0=b0+1
high 6

armed:
gosub key: if b1>128 AND b1<133 then initial
1
input 5:if pin5=1 then inputs
low 6: pause 30000: high 6                       ❷

inputs:
b5=b0 & 30:b7=0
for b6 = 1 to 3
b0=0
```

the Exit button or inserting the security key. Obviously the control box should be concealed to prevent an intruder finding it in time. You could make this period longer, or maybe the Exit button could be hidden close inside the Exit door instead of being mounted on the panel of the control box. Finally, the alarm is sounded, but to comply with local regulations, the program switches off the siren after a fixed period. The timing in this version of the program is 20 minutes or, more precisely, 18 times 65.535 seconds or 19.7 minutes.

SETTING UP

When the program has downloaded, disconnect the power supply to the circuit and disconnect the Stamp from the computer. Install the circuit in the control box, if not already there, insert a battery in the battery holder of the control box and also in that of the siren, if a separate battery is being used. The program starts running as soon as power is supplied. Press the reset button on the mother board to ensure that glitches have not let it get beyond the Initial stage.

Plug in the loop leads and siren lead. Close the box.

OPERATING INSTRUCTIONS

Follow this routine whenever you want to activate the system, or change the settings of the loop switches:

1 Insert the security key in its socket.

2 To check state of the loops, slide switches to the right. LEDs of loops 1 to 3 should be off, LED of loop 4 should be on. If incorrect, investigate accidentally open doors or windows or something wrong with other sensors.

3 For loops that are to be switched in, set its switch to the right. Set others to the left; if Loop 4 is switched out, its LED goes out.

4 Remove the security key.

5 The LED begins to flash after a few seconds (the loop 4 LED flashes off briefly and regularly too), indicating that the system is armed.

To change settings: reinsert security key, wait until the LED stops flashing, make changes, remove key.

To leave house: press and hold Exit Button until LED stops flashing. Leave house and shut door within 30 seconds.

On return to house: within 10 seconds of entering, either insert security key or press and hold Exit Button until LED stops flashing.

If siren sounds: take appropriate action. If this is a false alarm (unlikely, unless your sensors are too sensitive) open control box and press the reset button on the mother-board or remove power supplies.

```
gosub loopsin
if b0=b5 then repeat
b7=b7+1

repeat:
pause 5
next b6
if b7=3 then alarm
b0=b5
b3=b0 & 30
dirs=%11000000:b4=pins & b3
b5=0:if b3<16 then leave
b5=16

leave:
if b4=b5 then armed

alarm:
pause 10000
gosub key:if b1>128 AND b1<133 then initial
1
input 5:if pin5=0 then initial
low 7
for b6=1 to 18
pause 65535
next b6
high 7
end

key:
check:pause 20:pot 0,135,b1:pause 20:pot 0,135,b2
if b1=b2 then same
goto check

same:
return

loopsin:
for b2=1 to 4
pot b2,60,b3:if b3>0 then done
lookup b2,(0,2,4,8,16),b3
b0=b3+b0                                          ❸

done:
next b2
return
```

The numerals on the right are not part of the program but indicate references to the comments below:

❶. The scale values and limits allow a margin of 1 or 2 units in the results of 'pot'. The routine repeats until two identical consecutive readings have been obtained. Values will need to be changed if the resistor in the key is changed.

❷. The 30000 can be varied to obtain different delays.

❸. See discussion in text. Other loop arrangements will need other logic in these lines.

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Owen Bishop (1991) *Electronic Projects for Home Security*, PC Publishing, Tonbridge, Kent. ISBN 1 870775 12 0.

Owen Bishop (1993) *Alarmanlagen für den Selbstbau*, Elektor-Verlag GmbH, Aachen. ISBN 3 928051 31 8.

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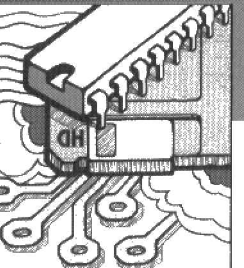

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Active probe	954093-1	8.00	16.00
Two-way PC-Fax Interface	954033	11.75	23.50
NOVEMBER 1995			
PIP Processor:			
- PCB + 87C51 (956505-1)	950078-C	54.75	109.50
- 87C51	956505-1	30.75	61.50
FM noise squelch	950089-1	10.75	21.50
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Jogging LED	950112-1	7.00	14.00
Oscilloscope prescaler	950115-1	27.75	55.50
OCTOBER 1995			
MatchBox BASIC computer:			
- PCB, 87C51, disk and Quick Reference Card	950011-C	59.25	118.50
- 87C51	956508-1	43.50	87.00
- Course diskette (DOS)	956009-1	11.50	23.00
- Quick Reference Card	950011-P	3.25	6.50
SEPTEMBER 1995			
Hi-Fi headphone amplifier	950064-1	5.00	10.00
Dongle safe:			
- PCB	950069-1	12.75	25.50
- GAL IC2 (20V8)	956511-1	10.00	20.00
- GAL IC6 (22V10)	956512-1	11.75	23.50
HexFET power amp upgrade:			
- amplifier PCB	930102	12.75	25.50
Copybit eliminator update:			
- PCB + MACH (956504-1)	950084-C	40.50	81.00
- MACH IC	956504-1	36.50	73.00
RF tone-dip oscillator	950095-1	5.25	10.50
JULY/AUGUST 1995			
Simple RF function generator	950023-1	7.50	15.00
Alkali/Manganese battery charger	950065-1	6.75	13.50
Fast charger for NiCd batteries:			
- PCB + ST62T20 (956509-1)	950076-C	22.75	45.50
- ST62T20	956509-1	14.75	29.50
Simple I/O card	954074-1	11 50	23.00
JUNE 1995			
Function generator			
- PCB	950068-1	29 50	59.00
- Front panel foil	950068-F	17 75	35.50
Electronic sandglass.			
- PCB + 87C751 (946647-1)	950052-C	26 25	52 50
- 87C751	946647-1	17.75	35.50
Auto light control	950050-1	4 75	9 50
VGA distribution amplifier	950017-1	10.00	20.00
MAY 1995			
MIDI analyser:			
- PCB + EPROM (956507-1)	940020-C	34.25	68 50
- EPROM	956507-1	16.75	33 50
Programmer for 87/89C51 series Flash controllers:			
- PCB + EPROM (956644-1)	950003-C	26.50	53 00
- EPROM	946644-1	14.50	29.00
Programmable sine wave generator			
- PCB + disk (956005-1)	950004-C	19.50	39.00
- control software on disk	956005-1	12.25	24.50
NiCd battery-quality tester:			
- PCB + ST62T15 (956506-1)	950051-C	25.25	50.50
- ST62T15	956506-1	18.25	36.50
APRIL 1995			
Sun blind control	950035-1	9.25	18.50
Function generator:			
- PCB + front panel foil	950044-C	21.75	43.50
- PCB	950044-1	11.00	22.00
- Front panel foil	950044-F	12.50	25.00
Stepper motor control:			
- PCB + 8751 + disk	950038-C	50.75	101.50

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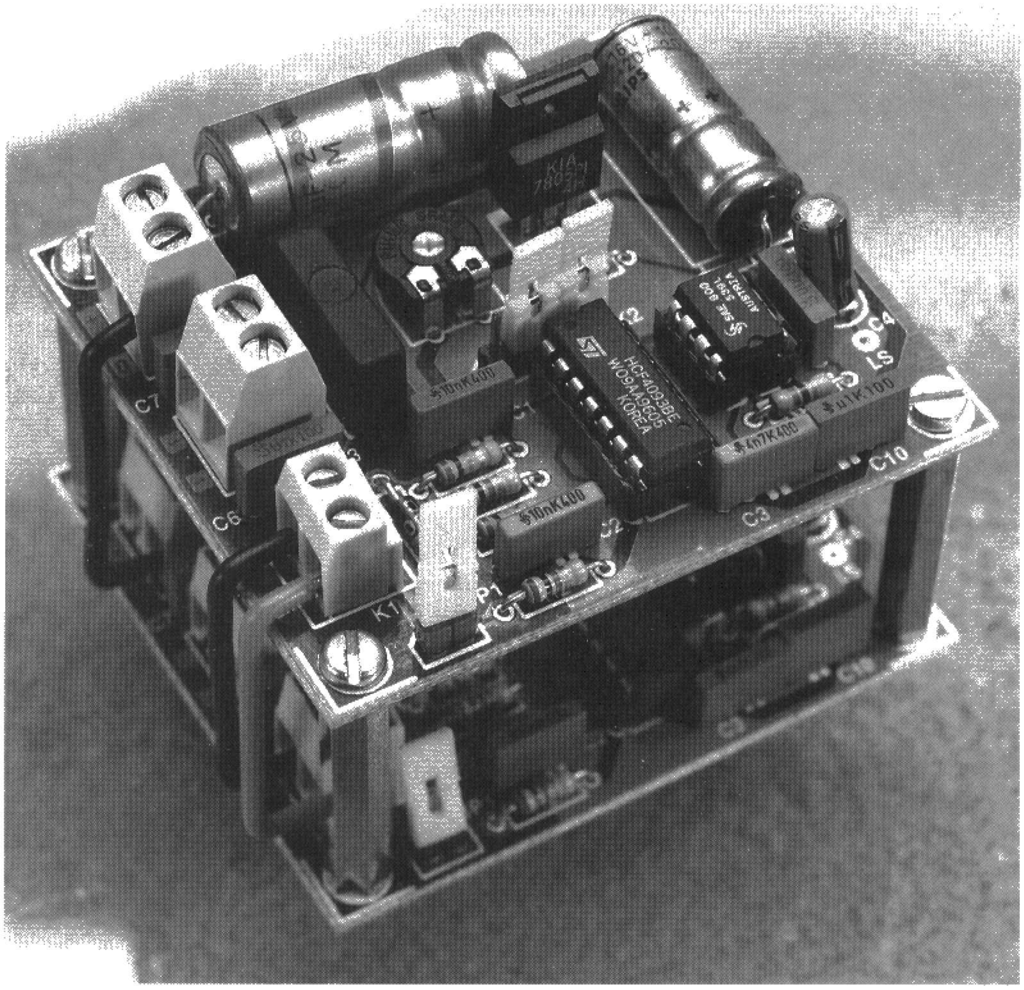
Elektor Electronics slipcase

Price £2.95 +P&P (£1.50 UK; £2.00 outside UK)

selective door chime



This circuit is for those of you who have a door bell switch installed on the front as well as on the rear door. Fine, but when using a single (very loud) bell or chime, you never know which door to answer.

This problem is solved by the present circuit which can be set to produce either two or three chime sounds. If you build two of these circuits, the one at the front door is set to produce, say, two tones, and the one at the rear door, three tones. It is even possible to couple the two circuits via terminal 'C' on the boards. This may be useful in large premises because it enables both chimes to sound irrespective which doorbell switch is pushed. In other words, the front door loudspeaker may produce a two-tone chime sound to indicate that you need to answer the rear door.

The circuit is based on the Siemens SAE0800, a three-tone chime IC with an on-chip integrated audio amplifier. The chime frequencies are determined by the oscillator frequency of the chip, which, in turn, depends on the value of the RC combination connected to pins 5 and 6. The loudspeaker volume is likewise set with a combination of a preset and a fixed resistor, here, R6/P1 at pin 4. The trigger inputs of the IC, E1 and E2, determine the number of chime notes generated by the IC, as follows:

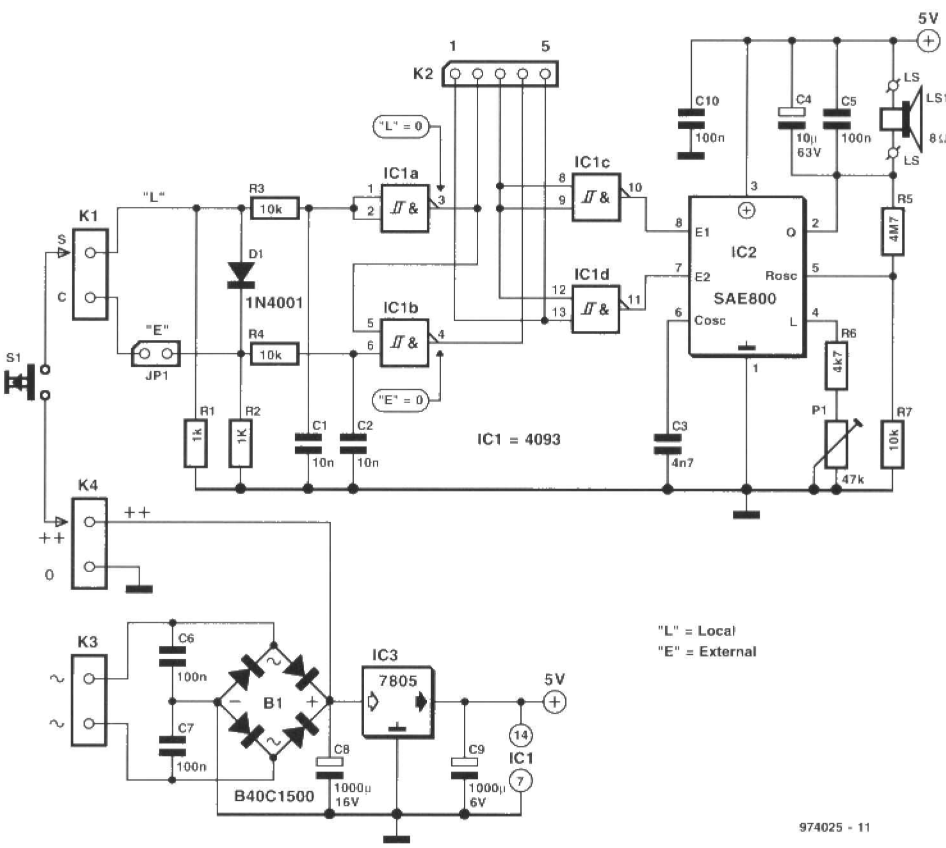
E1	E2	mode
↑	↑	3 tones
GND/n.c.	↑	2 tones
↑	GND/n.c.	1 tone

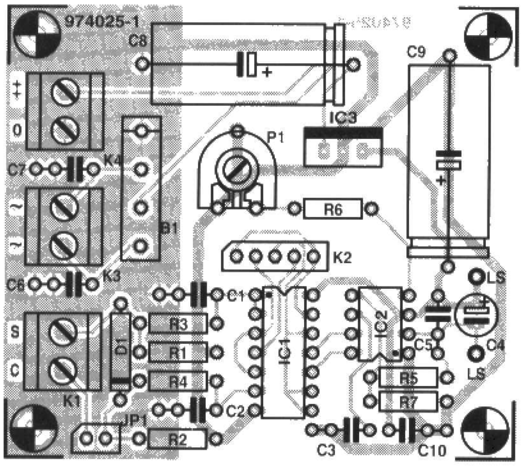
where ↑ indicates a rising edge.

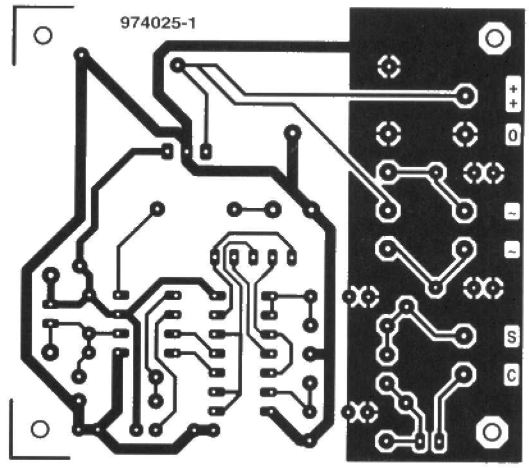
On one board, install **links 1-2 and 3-4** on pinheader K2 to select **two tones**. On the other board, **links 2-3 and 4-5** are installed to select **three tones**.

Each board has a simple rectifier and regulator circuit which allows it to be conveniently powered from an inexpensive a.c. output mains adapter. The quiescent current consumption is of the order of 5 mA. At the maximum sound volume (set with P1) this rises to about 400 mA.

If you decide to link the front and rear door chimes, you have to install jumper JP1 on both boards, and run a cable with at least two wires to interconnect the 'C' and ground ('0') terminals of the two units. Alternatively, use a three-wire cable, and feed the '++' voltage of one unit to the '++' terminal on the other. In







COMPONENTS LIST

Resistors:
R1,R2 = 1kΩ
R3,R4,R7 = 10kΩ
R5 = 4MΩ7
R6 = 4kΩ7
P1 = 47kΩ preset H

Capacitors:
C1,C2 = 10nF
C3 = 4nF7
C4 = 10µF 63V radial
C5,C6,C7,C10 = 100nF
C8 = 1000µF 16V
C9 = 1000µF 6V

Semiconductors:
B1 = B40C1500
D1 = 1N4001
IC1 = 4093
IC2 = SAE0800 (Siemens)
IC3 = 7805

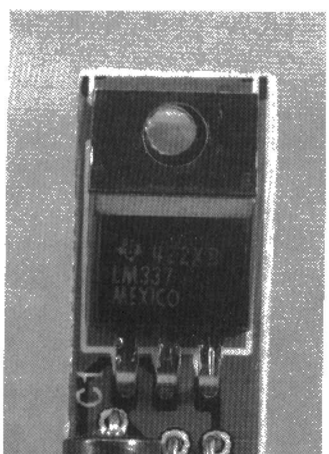
Miscellaneous:
K1,K3,K4 = 2-way PCB terminal block, raster 5mm
K2 = 5-way SIL pinheader
Ls1 = mini loudspeaker, 8Ω
JP1 = 2-way pinheader with jumper
S1 = doorbell switch
Printed circuit board, order code 974025

that case, you may omit the rectifier on the daughter board, and power both units from a single mains adapter.

The loudspeaker should be a miniature type rated at about 1 watt, and weather-resistant if necessary. A suggested type is the Monacor/Monarch SP-15 which has a plastic cone and achieves a sound pressure level of 96 dB at 1 watt.

(974025)

79xx replacement



The circuit shown in the diagram may prove useful when a 79xx voltage regulator needs to be replaced by a better quality type for which there is not enough space. It may also prove useful when a slightly different voltage is required.

The replacement circuit is based on a Type LM337 regulator from National Semiconductor. The IC and the three requisite external components are fitted on a tiny PCB whose terminals coincide with those of the terminals of a 79xx device. In other words, the board fits exactly where the 79xx used to be   it is, however, slightly higher.

The LM337 offers three advantages over a 79xx: (a) the ripple suppression is better; (b) the input voltage range is larger; (c) the output voltage can be arranged at any desired value with the aid of two standard resistors.

The resistors are calculated by

$$U_O = U_{REF}(1 + R_2/R_1).$$

In case of the LM337, U_{REF} is 1.25 V. The values of RF_1 and R_2 must ensure that the output current does not drop below 3.5 mA. With values as specified in the diagram, the output voltage is –15.3 V and the quiescent current is 4.6 mA.

The LM337 can provide output currents of up to 1.5 A. It may be necessary, depending on the dissipation, to mount the IC on a small heat sink.

Although not shown in the diagram, the IC needs decoupling capacitors of ≥ 100 nF at the input and 1 µF at the output. Since these are also required for the 78xx, it is assumed that these capacitors are already present.

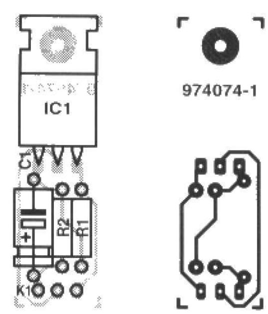
[Giesberts – 974074]

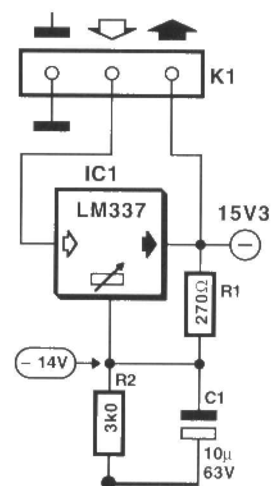
Parts list:

Resistors: *(U_0 = –15.3 V):*
R_1 = 270 Ω
R_2 = 3.0 kΩ

Capacitors:
C_1 = 10 µF, 63 V

Integrated circuits:
IC_1 = LM337





974074 - 11

mains on delay circuit

The delay is intended to switch on the mains to heavy loads gradually to ensure that the switch-on current remains within certain limits and to prevent the fuses from blowing. The elements that cause high currents at switch-on are, for instance, the electrolytic capacitors in the power supply of an output amplifier. Since these are not charged at switch-on, they constitute a virtual short-circuit on the supply lines. The current can, however, be kept within limits by inserting the present delay circuit between the mains outlet and the transformer primary. The amplifier is then powered in two stages: in the first instance, the current is limited by a number of heavy-duty series resistors; a second later these resistors are shunted (short-circuited) by a relay contact.

In the diagram, R_4–R_7 are the heavy-duty series resistors, each with a value of 10 Ω and rated at 5 W. They limit the switch-on current to about 5.5 A.

The relay is a type whose contact is rated at 2000 VA, which will be sufficient in most cases. Its supply is derived directly from the mains via potential divider R_3-C_1-B_1-relay coil. The resistor, R_3 limits the current at switch-on, after which C_1 limits the current in normal operation to about 20 mA. The delay time is determined by electrolytic capacitors C_2 and C_3 in parallel with the relay. The delay time may be altered by suitably changing the value of one or both of these capacitors.

For safety's sake, the board also has provision for a mains fuse, F_1. The rating of this depends, of course, on the current drawn by the load.

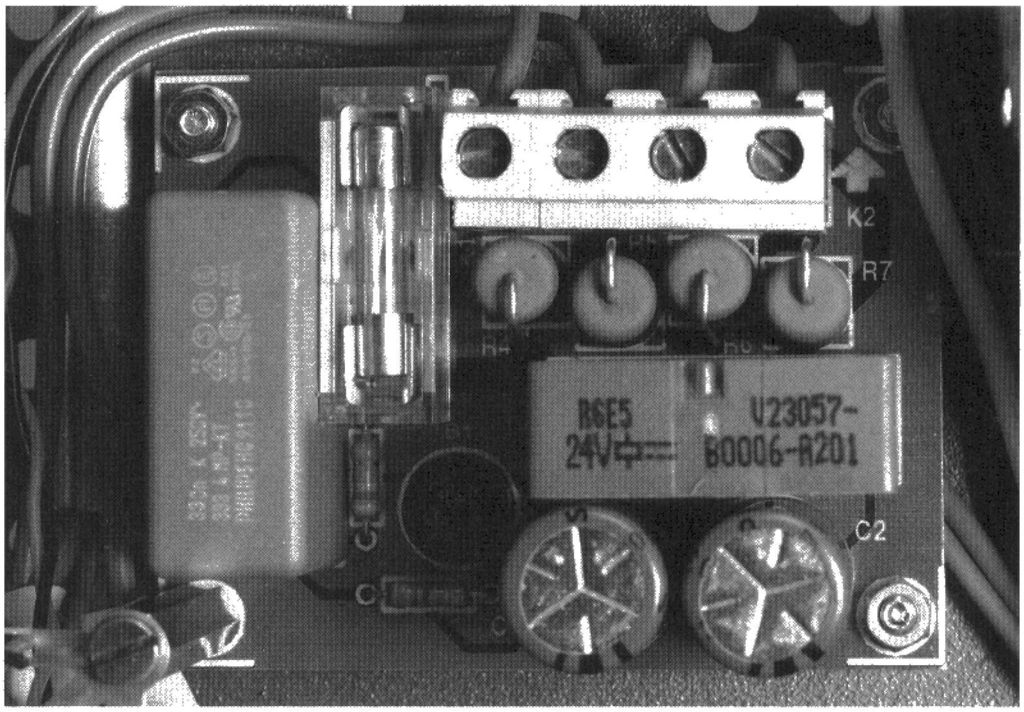
It should be noted that in the case of a double-mono stereo output amplifier (with separate power supplies) each of the mono amplifiers must be given a mains-on delay.

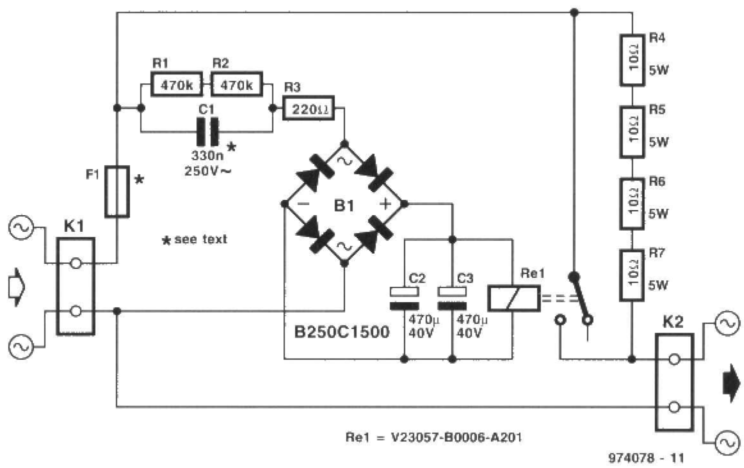
As mentioned earlier, the values of R_4–R_7 refer to a switch-on current of about 5.5 A. If the power rating of the load is lower than 200 VA, it is advisable to use resistors with a slightly higher value.

Note that C_1 is a metallized paper type, which is designed specially for mains voltage applications and meets stringent regulatory requirements.

Finally, at all times bear in mind that the circuit is connected to the mains, so do not touch anything inside the unit during operation and make sure that all wiring is safe and secure.

[Giesberts - 974078]



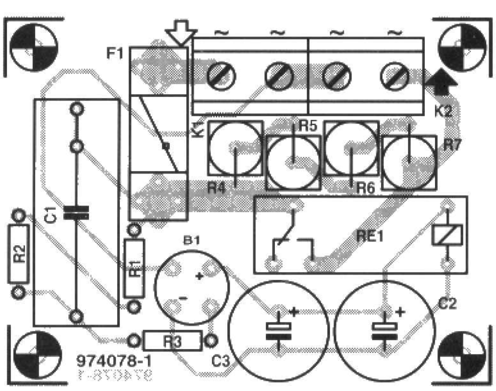


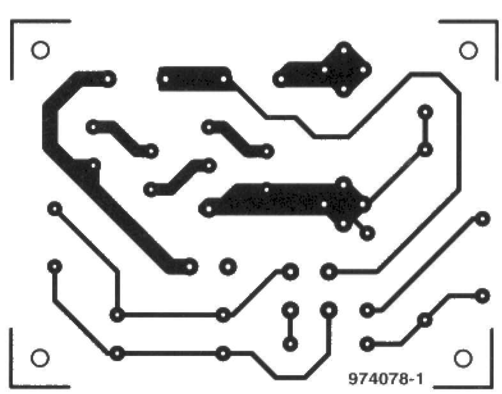
Parts list

Resistors:
R_1, R_2 = 470 kΩ
R_3 = 220 Ω
R_4–R_7 = 10 Ω, 5 W

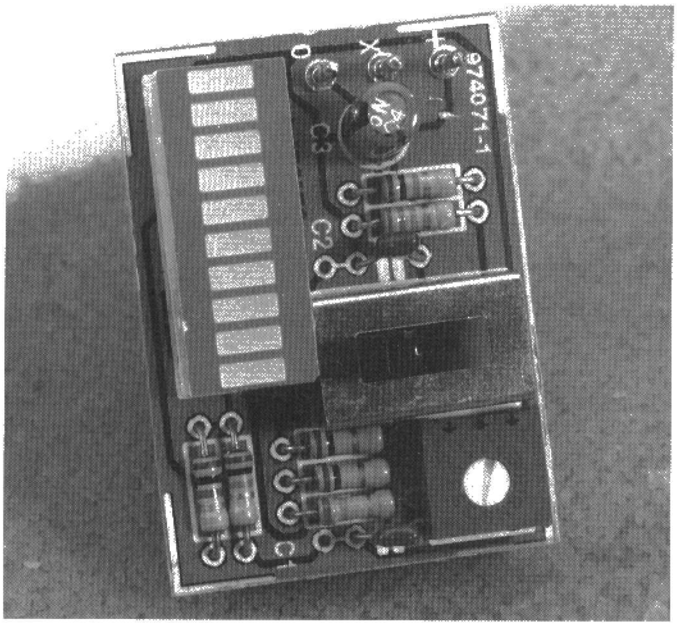
Miscellaneous:
K_1, K_2 = 2-way terminal block, pitch 7.5 mm
B_1 = B250C1500, round
Re_1 = contact rating 250 V, 8 A, coil 24 V, 1200 Ω
F_1 = see text

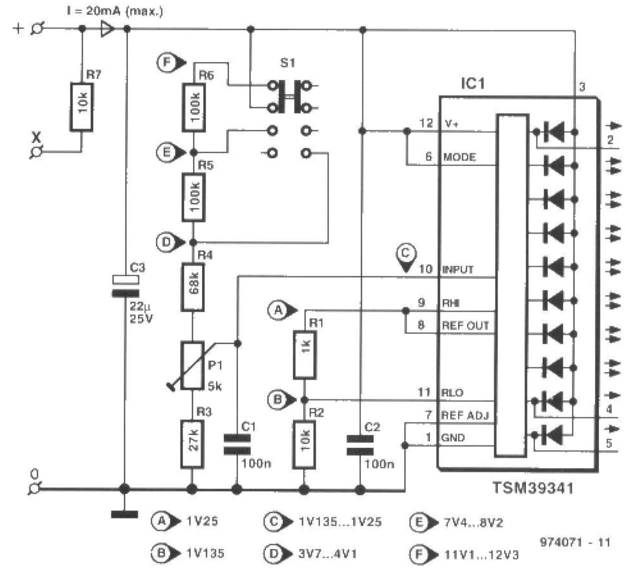
Capacitors:
C_1 = 0.33 µF, 250 VAC, metallized paper
C_2, C_3 = 470 µF, 40 V





Li-Ion battery capacity meter





This little circuit exploits the fact that the remaining capacity of a Lithium-Ion (Li-Ion) rechargeable battery is virtually proportional to the battery voltage.

When discharged with a constant current a single Li-Ion cell is marked by an almost linear voltage decrease from about 4.1 V (fully charged) down to about 3.5 V (10% charge left). So, all you need to measure the battery capacity is an accurately defined, small, voltage window with a span of 3.5 to 4.1 volts, and a calibrated voltmeter or equivalent circuit providing a percentage readout.

Li-Ion batteries usually come in one of three shapes: single-cell (4.1 V), dual-cell (8.2 V) and three-cell (12.3 V). The indicated voltages apply to fully loaded batteries. The 12.3 V block is a particularly popular type as it is often used in camcorders. The BT-L1 block as used in Sharp camcorders is probably the best known.

This tester us suitable for all three Li-Ion battery types mentioned above. The number of cells of the battery to be tested is set with slide switch S1. A conventional resistor ladder is used to reduce the battery voltage to a level which is suitable for applying to the input of IC1, an integrated ADC with direct LED drive outputs. Although the operation of the TSM39341 is similar to that of the familiar LM3914, a major difference is the LED array which is internal to the chip.

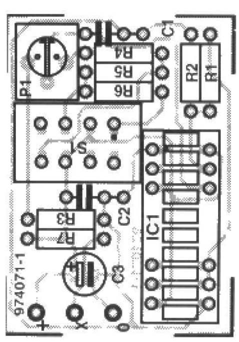
The TSM39341 is wired to drive the 10 LEDs in 'bar' mode (as opposed to 'dot' mode). The LED drive current is set to about 1.3 mA per LED by R1 and R2.

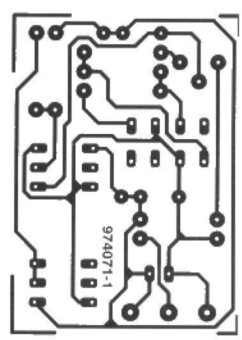
Resistor R7 is necessary to flag 'all-clear' to the output protection circuit built in the Sharp BT-L1 battery.

The circuit is simple to adjust: connect a fully charged Li-Ion battery, set the slide switch to the appropriate range (4.1 V, 8.2 V or 12.3 V), and adjust P1 until the '100%' LED just lights.

Unfortunately, the printed circuit board shown here is not available ready-made through the Readers Services.

(974071)





COMPONENTS LIST

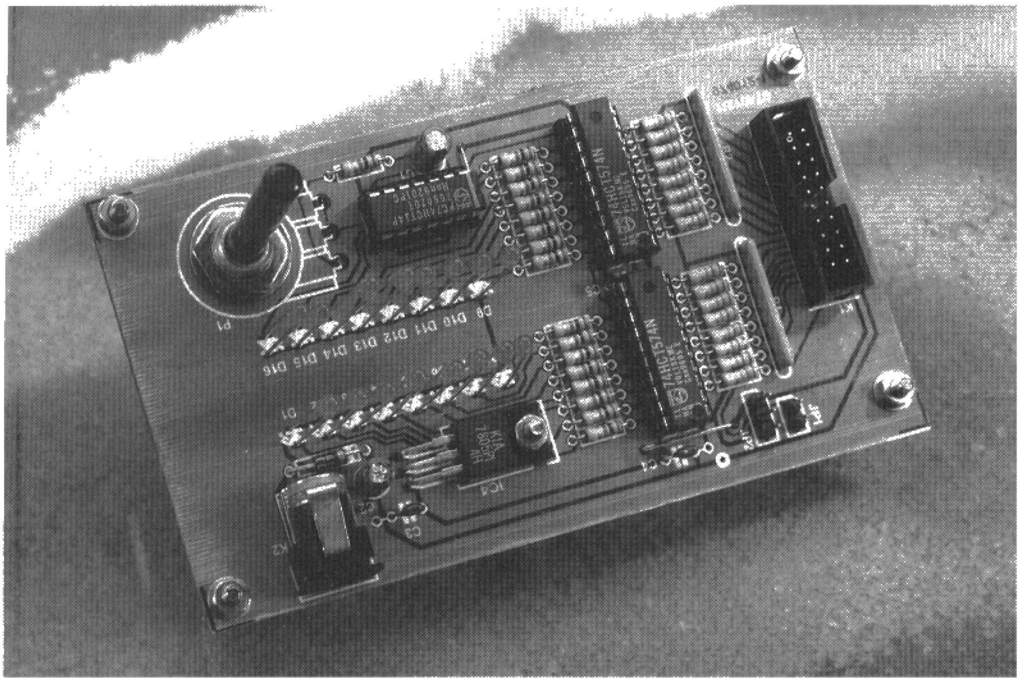
Resistors:
R1 = 1kΩ
R2,R7 = 10kΩ
R3 = 27kΩ
R4 = 68kΩ
R5,R6 = 100kΩ
P1 = 5kΩ preset H

Capacitors:
C1,C2 = 100nF
C3 = 22µF 25V radial

Semiconductors:
IC1 = TSM39341 (Farnell order code 324-012)

Miscellaneous:
S1 = slide switch, PCB mount, 3 positions, 2 rows of 4 contacts.

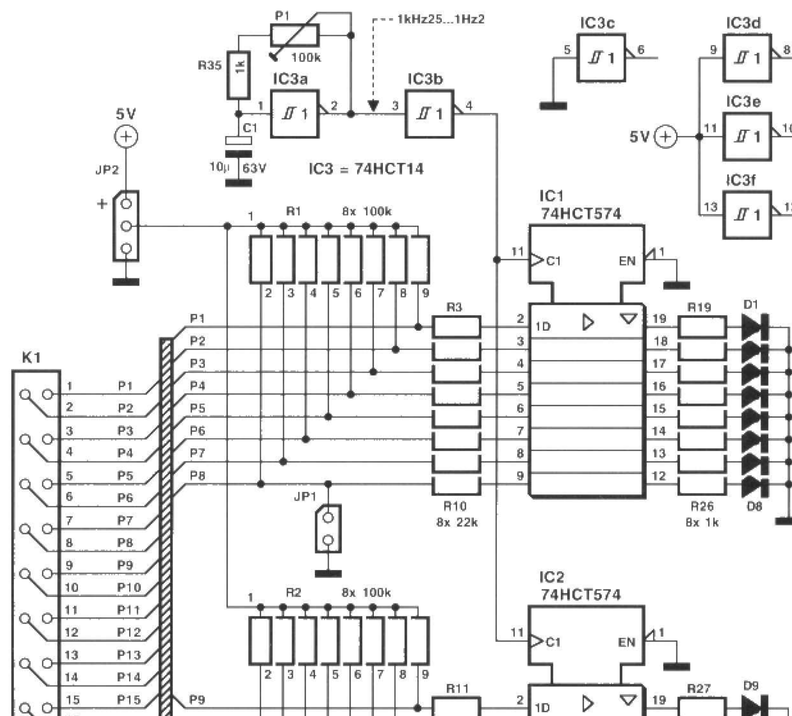
digital tester



The tester provides 16 LEDs arranged on the board in the shape of a 16-pin DIL package. Each of these LEDs indicates the logic level present at the corresponding pin of the logic IC whose function you wish to examine. This is achieved by placing a 16-way test clamp on to the IC under test, and feeding the logic levels to the present tester via a 20-way flatcable. Obviously, as the (corner) supply pins of the IC under test are also included, the relevant indicator LEDs will show a permanent logic 0 for the Vss or GND pin, no. 7 or 8, and a logic 1 for the Vdd/Vcc pin, no. 14 or 16.

The circuit consists of two clocked octal bistables/latches type 74HCT574. Each latch drives a LED via a current limiting resistor (R19 through R34). The set of logic levels at the latch inputs is refreshed with the aid of a common clock signal supplied by a two-gate free-running R-C oscillator built around IC3a and IC3b. Potentiometer P1 allows the refresh frequency to be adjusted to any value between about 1.2 and 1250 Hz. The 'display refresh' gives the user an idea about the functioning of a suspect IC, and allows him/her to draw up elementary truth tables.

Apart from the 16 logic levels the flatcable between the tester and the circuit under test also carries the +5 V supply voltage (pins 17/18) and ground (pins 19/20). The relevant four wires are separated from those connected to the 16-way DIL clamp.



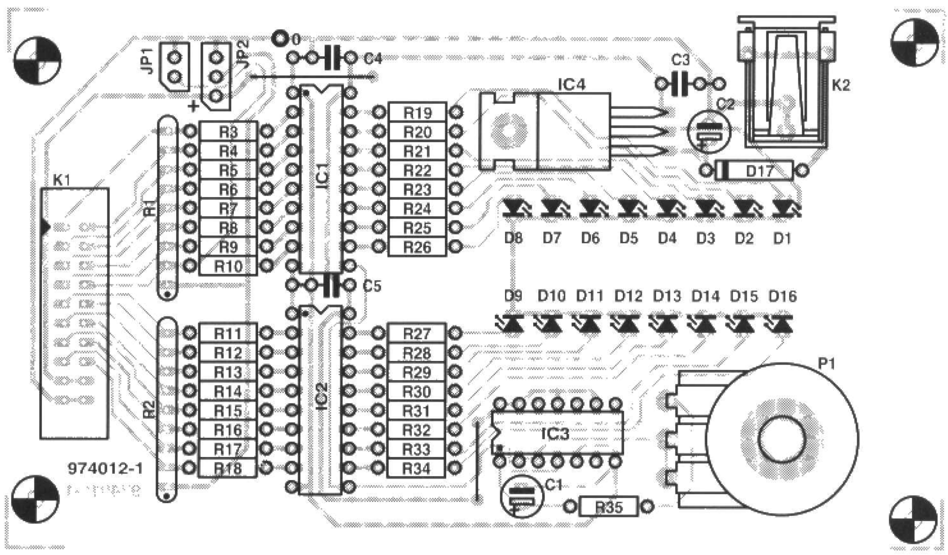
Normally, a flexible ground wire is taken from wires 19/20 and connected to ground of the circuit under test, while the +5 V wires are not used. Alternatively, the tester may power the circuit under test via the +5 V wires, but only if it is capable of sourcing the requisite current.

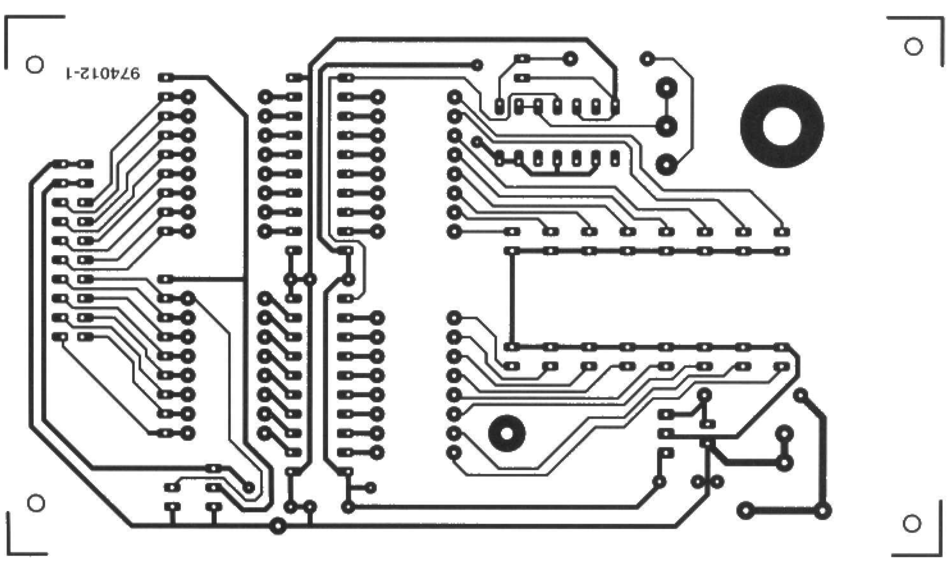
As pin 8 of the IC under test will usually be at ground potential, the corresponding input line may be tied to ground permanently with the aid of jumper JP1.

The common junctions of resistor arrays R1 and R2 may be tied to ground or +5 V, depending on the type of logic circuit you are checking out. For regular TTL, set JP2 = +, for CMOS, set JP2 = –.

Current consumption of the tester is greater than 30 mA with all LEDs on. The minimum direct voltage applied to power socket K2 is 8.5 V from a small mains adaptor.

(974012 - P. Veltkamp)





COMPONENTS LIST

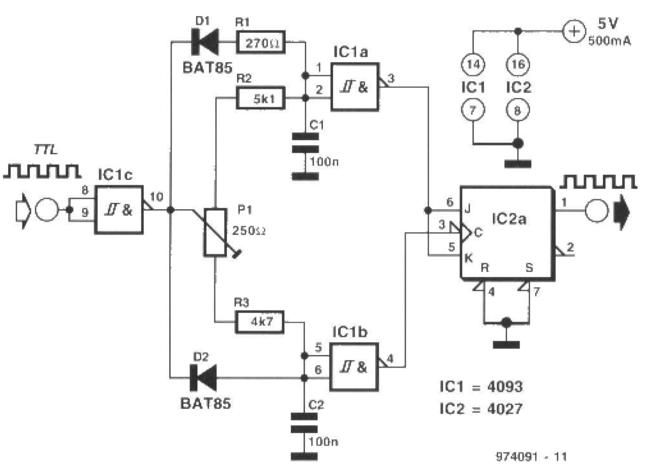
Resistors:
R1,R2 = 100kΩ 8-way SIL array
R3-R18 = 22kΩ
R19-R35 = 1kΩ
P1 = 100kΩ linear potentiometer

Capacitors:
C1,C2 = 10µF 63V radial
C3,C4,C5 = 100nF

Semiconductors:
D1-D16 = LED high efficiency
D17 = 1N4001
IC1,IC2 = 74HCT574
IC3 = 74HCT14
IC4 = 7805

Miscellaneous:
JP1 = 2-way pinheader, 1 jumper
JP2 = 3-way pinheader 1 jumper
K2 = mains adaptor socket, PCB mount
K1 = 20-way boxheader or pin-header
Printed circuit board, order code 974012-1

quasi-digital bandpass filter



This simple filter ensures that TTL signals are transferred within a certain frequency range, though at half their original frequency. Below and above this range, the filter output is a stable logic level.

The square wave signal at the input is delayed by networks R_2-C_1 and R_3-C_2. Accordingly, after a brief delay, a logic 1 at the input appears at the output of both gates in the 4093, whereas, owing to the use of diodes, the transfer of a 0 is not, or hardly, delayed. Provided the circuit is set up correctly, its operation is as follows.

Well below the cut-off point, the clock as well as the JK signal are delayed. The delay of the JK signal is somewhat longer, however, owing to network R_2-C_1.

The data at the JK inputs written by the bistable at the leading edge of the clock signal is low. The outputs then remain stable.

Just below the cut-off point, network R_2-C_1 can no longer follow the signal. The level at the input of IC_{1a} is then low and that at the JK inputs of IC_2 is high.

Since the clock signals continue to be transferred, the bistable receives clock pulses and becomes a binary scaler.

When the frequency rises further, the clock will no longer reach the bistable. The last attained position is then stored.

With values as specified in the diagram, the signals that are transferred lie in the frequency range 795–935 H when P_1 is fully anti-clockwise and 830–930 Hz when P_1 is fully clockwise.

The filter draws a current of ≤ 1 mA.

(Serper – 974091)

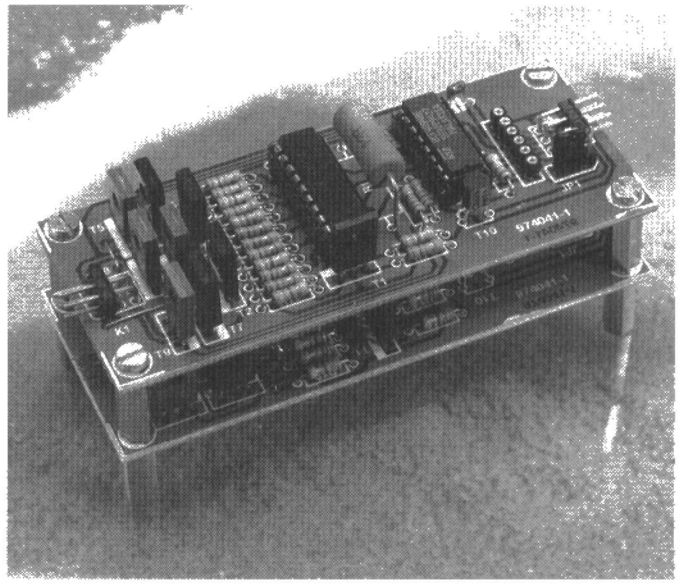
PC controls two stepper motors

This circuit allows a PC or a suitably programmed microcontroller system to control a stepper motor. Rather than relying on the latest in dedicated motor controller ICs, this interface is based on ordinary CMOS logic, discrete transistors and one ULN power driver IC. The interface is designed with extension in mind, because a doughterboard may be added to control a second stepper motor. Programmers will like the accompanying Pascal program as starting point for further experiments. The program allows the interface to be driven by the PC's parallel port. Alternatively, you may use a microcontroller's serial port to control the interface. The 2-to-3 wire interface converter described elsewhere in this issue (ref. 974113) is suitable for the job.

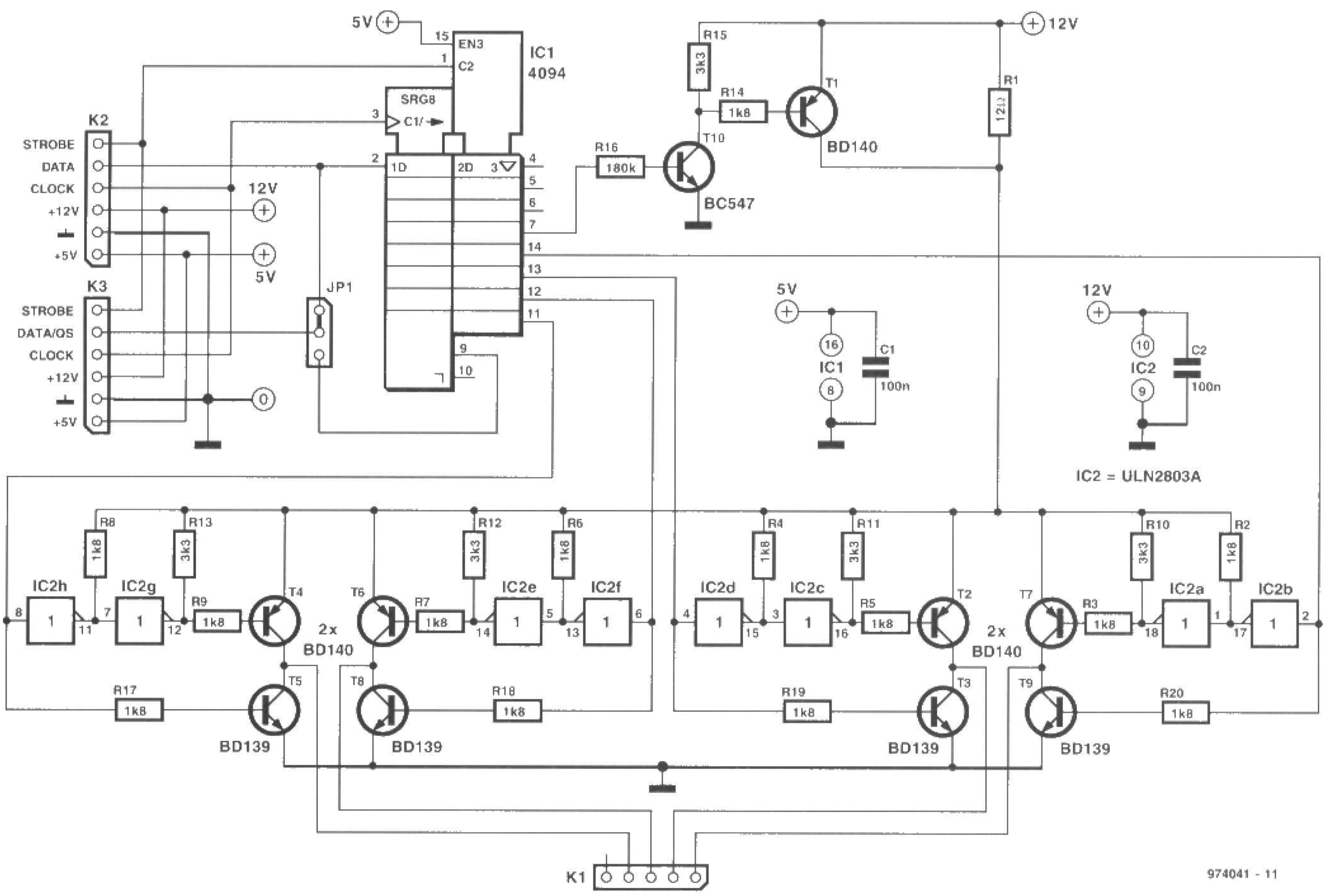
Printer port data lines D1, D2 and D3 are connected to the strobe, data and clock inputs, respectively, of pin-header K2, which also receives a 5-V supply voltage for the logic circuits, and 12 V for the motor drivers.

The 4094 (IC1) is a CMOS 8-bit latching shift register with 3-state outputs. Only five of the eight shift register outputs are used here, the remaining ones are available for extension experiments. The motor driver transistor pairs, T2-T9, are controlled by shift register outputs Q5-Q8 via ULN2803 buffers/inverters which help to convert from 5 V to 12 V logic.

Resistor R1 acts as a current limiter when the stepper motor is not active. When control signals are generated,



```
program stepper motor;

uses crt;

const portAddr=$3BC;
      motors=2;

var counter, a: integer;

procedure Low;
{Load one LOW bit in shift register}
begin
     port[portAddr]:=$4; { [0100]b }
     port[portAddr]:=$0; { [0000]b }
end;

procedure High;
{Load one HIGH bit in shift register}
begin
     port[portAddr]:=$2; { [0010]b }
     port[portAddr]:=$6; { [0110]b }
     port[portAddr]:=$0; { [0000]b }
end;

procedure Strobe;
{Create STROBE signal for shift registers
to latch contents of shift reg. to output}
begin
     port[portAddr]:=$1; { [0001]b }
     port[portAddr]:=$0; { [0000]b }
end;

procedure Init;
{Makes all outputs of shift register(s) LOW}
begin
     port[portAddr]:=$0; { [0000]b }
     for counter := 1 to (8*motors) do Low;
     Strobe;
end;

procedure Step1;
{Load pattern for Step1 [1000 1000]b }
begin
     High; Low; Low; Low; High; Low; Low; Low;
end;

procedure Step2;
{Load pattern for Step2 [0010 1000]b }
begin
     Low; Low; High; Low; High; Low; Low; Low;
end;

procedure Step3;
{Load pattern for Step3 [0100 1000]b }
begin
     Low; High; Low; Low; High; Low; Low; Low;
end;

procedure Step4;
{Load pattern for Step4 [0001 1000]b }
begin
     Low; Low; Low; High; High; Low; Low; Low;
end;

procedure Step2Res;
{Load pattern for Step2 with R3 in series
 [0010 0000]b }
begin
     Low; Low; High; Low; Low; Low; Low; Low;
end;

procedure Step4Res;
{Load pattern for Step4 with R3 in series
 [0001 0000]b }
begin
     Low; Low; Low; High; Low; Low; Low; Low;
end;

begin
    {User defined}
     ClrScr;
     Init;
     for a:= 1 to 50 do
     begin
         {Example causes one (slow) turn of both
          motors in opposite direction.
          mot_2; mot_1; strobe1+2; Delay
          --+------+-------+-------+-----
            |      |       |       |
            V      V       V       V                }
          Step1; Step4; Strobe; delay(10);
          Step2; Step3; Strobe; delay(10);
          Step3; Step2; Strobe; delay(10);
          Step4; Step1; Strobe; delay(10);
     end;
     delay(1000);
     for a:= 1 to 50 do
     begin
         {Example causes one (fast) turn
          of both motors in opposite direction.
          mot_2; mot_1; strobe1+2; Delay
          --+------+-------+-------+-----
            |      |       |       |
            V      V       V       V                }
          Step4; Step1; Strobe; delay(5);
          Step3; Step2; Strobe; delay(5);
          Step2; Step3; Strobe; delay(5);
          Step1; Step4; Strobe; delay(5);
     end;
     Step2Res;Step2Res;
     Step4Res;Step4Res;
     Strobe;
end.
```



R1 is virtually short-circuited by T1. The program as printed here is based on the assumption that two interface boards are used to drive two motors. If you use only one motor, the first 8 of 16 bits transmitted to the interface will be lost (see below) unless you make appropriate changes to the software (basically, you have to remove all references to mot_2, and change the constant 'motors=2' to 'motors=1'). Food for programmers! The program works basically as follows. Let's assume a '1' arrives at the D (data) input of IC1. When the clock input is pulled high, the rising pulse edge causes the '1' at the data input to be read into the shift register. In this way, the shift register is filled with 8 bits (ones and/or zeroes). Next, the strobe line (Centronics data line D1) is pulled high so that the shift register contents are copied and latched by the IC outputs, and the power transistors are driven accordingly.

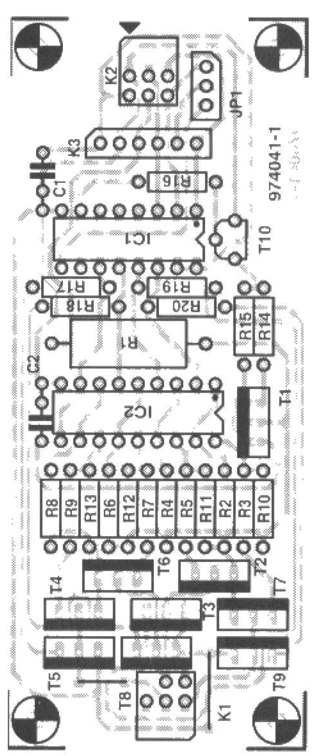
The printed circuit board layout indicates that K1 is a 6-way pinheader block (2 rows of 3 pins) of which pin 1 is removed. This done to make sure the stepper motor connector can not be connected the wrong way around.

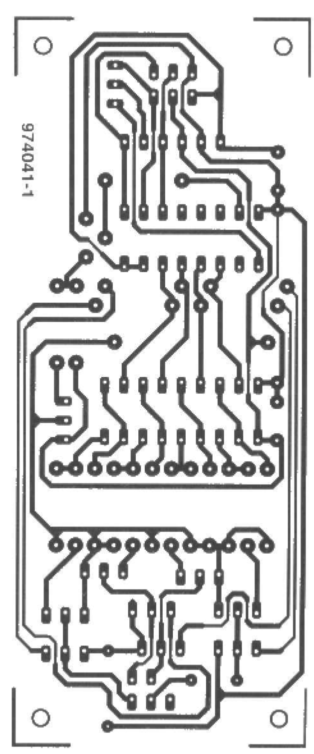
A doughterboard may be added for the control of a second stepper motor. This is achieved by assembling the two boards in a stacked ('sandwich') construction and interconnecting their pinheaders K3. On the **master board** (i.e., the one connected to the PC), fit **JP1 in position 2-3**. On the **doughterboard**, fit **JP1 in position 1-2**. This links the data pin of K3 to the data input of IC1 on the doughterboard. By the way, position 1 of the jumper block is marked by the bevelled edge as shown on the component overlay.

Stacking the boards and the jumper arrangement allow a 16-bit control word (supplied by a suitably modified program) to be split up into two words intended for the motors driven by the main board and the doughterboard. The first 8 bits always go to the doughterboard.

Unfortunately, the printed circuit board shown here is not available ready-made through our Readers Services.

Although only very small currents will be required, the 5-V supply for IC1 has to be regulated. Not so for the 12-V supply, which may be unregulated but capable of furnishing all current required by the stepper motor(s). (974041 L. Ferger)





COMPONENTS LIST

Resistors:
R1 = 12Ω 5 watt
R2-R9,R14,R17-R20 = 1kΩ8
R10-R13,R15 = 3kΩ3
R16 = 180kΩ

Capacitors:
C1,C2 = 100nF

Semiconductors:
T1,T2,T4,T6,T7 = BD140
T3,T5,T8,T9 = BD139
T10 = BC547
IC1 = 4094
IC2 = ULN2803A (Sprague)

Miscellaneous:
K1 = 6-way pinheader (2x3 pins) angled (see text)
K2 = 6-way pinheader (2x3 pins) angled
K3 = 6-way pinheader (1x6 pins)
JP1 = 3-way pinheader with jumper

scarecrow

It is quite common in certain areas that from time to time a flight of starlings comes down into a tree. Sometimes there are so many that the tree bends under their weight. And, of course, the amount of droppings below the tree does not do your garden (or your car) much good. The scarecrow tells these birds in an environment-friendly as well as bird-friendly way to go elsewhere.

An oscillator, IC_1, generates pulse trains whose width, repetition rate and pattern are variable. Its pulse-shaped output signal is used to drive a piezo buzzer via a darlington transistor, T_1. Power is derived from a variable current source based on T_2. The buzzer can create sound pressures of up to 100 dB – enough to drive away even the most determined starling.

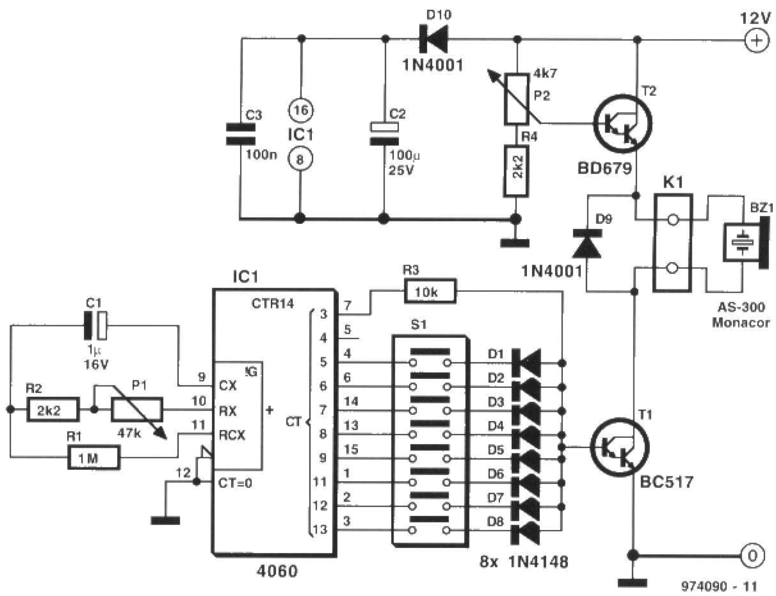
Up to 256 bit patterns may be set with S_1 to make sure that the birds do not get used to one particular sound.

The oscillator frequency is determined by R_1-R_2-C_1-P_1 and may be set with P_1 to a pulse repetition frequency (p.r.f.) of 0.5–5 Hz.

Transistor T_1 is on as soon as Q_3 and those of outputs Q_5–Q_{13} whose switch is closed are high.

The current drawn by the circuit is primarily that of the buzzer which is <150 mA. It is, therefore, advisable to use a (simple) mains adaptor as the power source.

[Bonekamp - 974090]

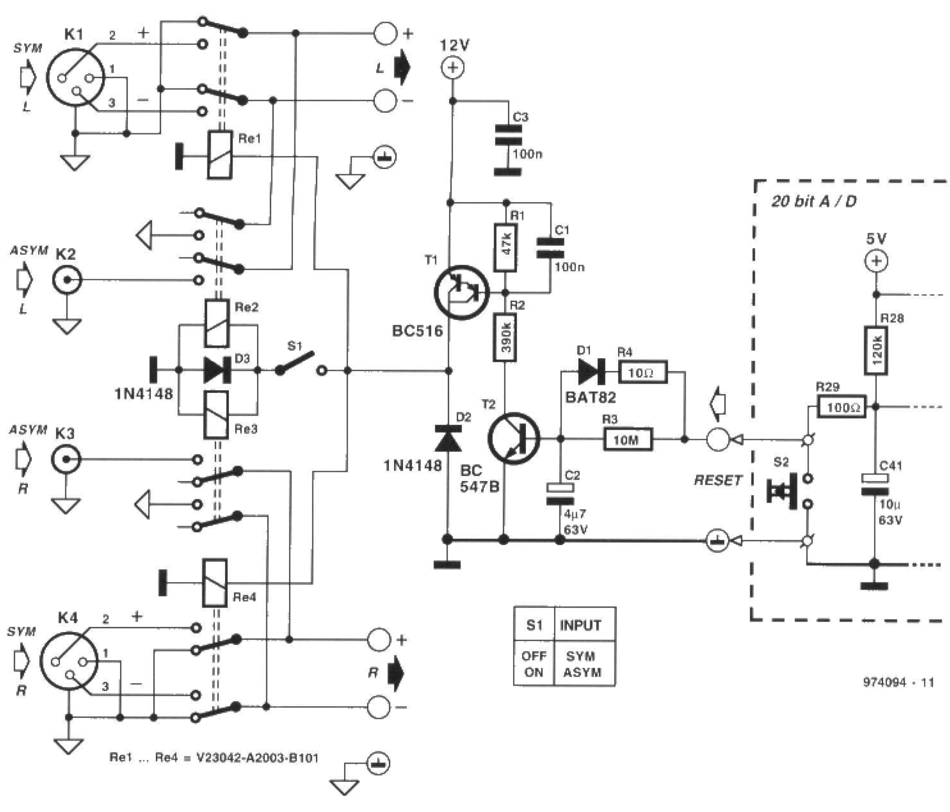


XLR-to-audio-socket switch

The 20-bit ADC in the December 1996 issue of this magazine was fitted with symmetrical inputs (as is usual in a professional appliance). However, in view of non-professional readers, the unit was also able to process asymmetrical signals. The unit may be extended with normal audio sockets to make working with asymmetrical signals a little easier. How this may be done is shown in the diagram.

In fact, all that is necessary to make the input stage accept asymmetrical signals is linking pin 3 of the XLR buses to earth, whereupon this pin can be used as the earth for audio sockets. In the proposed circuit, this is done with the aid of relays Re_2 and Re_3. By using further relays, Re_1 and Re_4, for linking and passing the signal as relevant, a single switch (S_1) suffices to change over from XLR buses K_1–K_4 to audio sockets K_2 and K_3.

Transistors T_1 and T_2 have a dual function: (a) they provide level matching between the digital circuit



S1	INPUT
OFF	SYM
ON	ASYM

in the ADC (5 V) and the relay circuit (12 V); (b) they provide a switch-on delay whereby after the power is switched on, or after a reset (S_2), the inputs are briefly linked to earth via Re_1 and Re_4. This makes it possible for the input stage to be included in the offset calibration of the ADC.

When the reset switch (S_2) on the ADC is operated, C_2 is discharged rapidly via R_4 and D_1. Network R_3-C_2 then ensures that the relays remain reset for about four seconds. This network has been made high-impedance on purpose, since it must not affect the reset network of the ADC itself (in dashed box). Capacitor C_1 provides further decoupling of any interference pulses. Diodes D_2 and D_3 are free-wheeling devices.

The signal earth must be isolated from the relay earth.

It has been assumed that the relays are powered by a separate 12 V line. The 12 V line for the analogue input stage of the ADC must not be used, however, because this cannot provide the requisite current of some 80 mA.

It is inherent in the circuit that the asymmetrical signals applied to K_2 and K_3 are passed on to pins 2 of K_1 and K_4, and that pins 3 of these buses are short-circuited, when S_1 is closed. This means that only one stereo source can be connected at any one time.

[Giesberts - 974094]

AES/EBU-to-S/PDIF converter

The converter is intended primarily for use with the sample rate converter published in the October 1996 issue of this magazine.

The conversion of a symmetrical signal to an asymmetrical one requires no more than a small transformer. Amplification is not required since the AES/EBU signal is strong enough to generate the S/PDIF signal (500 mV_{pp} into 75 Ω). However, the quality of the conversion depends entirely on that of the DIY transformer.

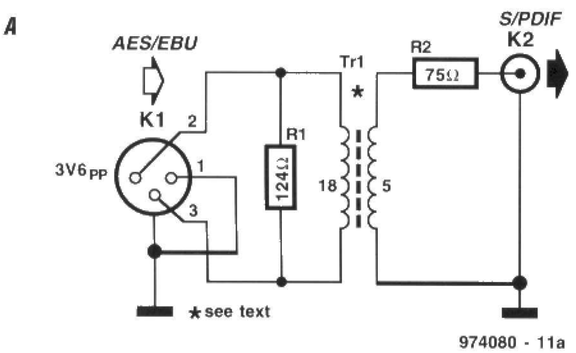
The simplicity of the circuit means that the turns ratio depends on the level of the symmetrical input voltage. This is the reason that the diagram shows two versions. Version A is suitable for inputs of 3.6 V_{pp} and Version B for inputs of 5 V_{pp}.

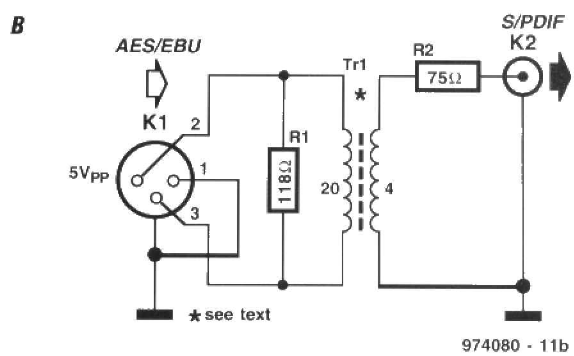
The transformer is wound on a Type G2-3/FT12 core. The primary as well as the secondary are wound from enamelled copper wire of 0.5 mm dia. The transformer for Version A needs a primary winding of 18 turns and a secondary of 5 turns. That for Version B requires a primary of 20 turns and a secondary of 4 turns.

The secondary impedance is transformed to the primary winding. Assuming that the system has a correctly terminated output of 75 Ω, the primary winding needs to be shunted by a resistor, R_1, of 124 Ω (Version A) or 118 Ω (Version B) to give an input impedance of 110 Ω. This arrangement ensures a correct input impedance over a wide range of input frequencies. Only at 60 kHz (Version A) or 50 kHz (Version B) does the impedance drop by about 20%.

The bandwidth of the converter is ≥ 20 MHz.

(Giesberts 974080)

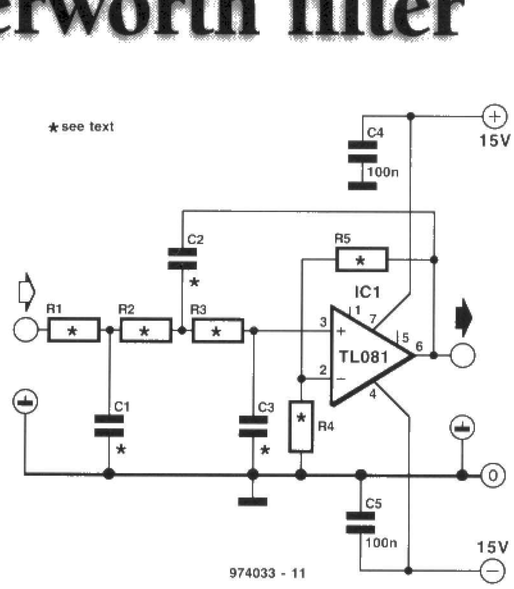




active Butterworth filter

Active filters are invariably designed with a unity-gain buffer. In fact, this has become such a habit that one is inclined to think that it is obligatory, which of course it is not. An active filter can easily be designed with an amplifier without making it less accurate. This has real benefits for in many cases it means that an entire stage may be omitted from the relevant amplifier.

It is a fact, however, that the degree of amplification has a direct effect on the filter characteristic. This means that the values of the filter components must be in accord with the amplification factor.



A	dB	R4	R5
1	0	----	0
1.7783	5	1k00	0.7783 x R4
2	6	1k00	1k00
3.1623	10	1k00	2.1623 x R4
5	14	1k00	4 x R4
10	20	1k00	9 x R4

Table 1. R1 = R2 = R3 = 10.0 kΩ; $f_{-3\,dB}$ = 1 kHz.			
Amplification	**C1 (nF)**	**C2 (nF)**	**C3 (nF)**
×1 (0 dB)	22.1650	56.4490	3.22210
×1.7783 (5 dB)	26.4250	15.4990	9.84350
×2 (6 dB)	27.1490	13.8000	10.7600
×3.1632 (10 dB)	30.1370	9.43930	14.1720
×5 (14 dB)	33.5670	6.82040	17.6090
×10 (20 dB)	39.8850	4.33420	23.3210

Table 2. $f_{-3\,dB}$ = 1 kHz.						
Amplification	**C1 (nF)**	**R1 (kΩ)**	**C2 (nF)**	**R2 (kΩ)**	**C3 (nF)**	**R3 (kΩ)**
×1 (0 dB)	22	9.9800	56	10.2670	3.3	9.6776
×1.7783 (5 dB)	27	9.3281	15	10.6770	10	9.9944
×2 (6 dB)	27	10.1810	15	9.5328	12	8.5469
×3.1632 (10 dB)	33	8.9814	10	9.4475	15	9.5983
×5 (14 dB)	33	9.9922	6.8	10.2730	18	9.7229
×10 (20 dB)	39	8.8965	3.9	12.0950	22	11.1970

A further, slight, drawback is that as the amplification increases, the properties of the op amp used will have a greater effect on the signal transfer. Designers therefore use a high-speed op amp if the amplification is greater than, say, ×3. Since, however, the effect of the op amp at frequencies below 1 kHz is not great anyway, in most cases the op amp specified (TL081) will give excellent service.

The amplification of the op amp in the present circuit is $\alpha = 1+R_5/R_4$. The table in the diagram gives values for R_4 and R_5 for a number of amplification factors.

To make the arithmetic a little easier, the tables in the text give the values of the frequency-determining components for a 3rd order Butterworth filter with a cut-off frequency of 1 kHz for the same amplification factors as in the table in the diagram.

Table 1 is based on the assumption that $R_1=R_2=R_3$ = 10.0 kΩ, which results in awkward values of C_1–C_3 that will have to be resolved by series and parallel connecting of 1% capacitors.

Table 2 is based on standard values for C_1–C_3, which results in non-standard values for R_1–R_3, which are, however, fairly close to E96 values.

The filter in the diagram is a low-pass section, which may be converted to a high-pass section by interchanging C_1–C_3 and R_1–R_3 (which means, of course, that the values of the components will have to be recalculated). The ratios of the component values indicated in the tables will remain the same.

The filter draws a current of only a few milliamperes.

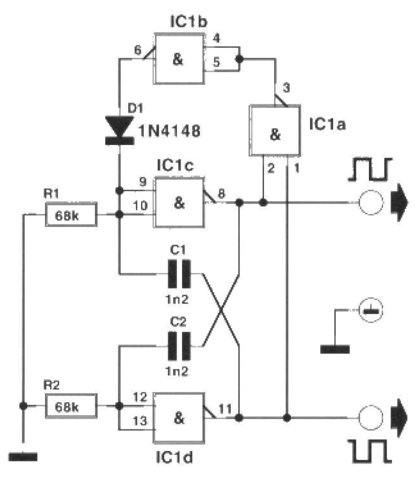
[Giesberts 974033]

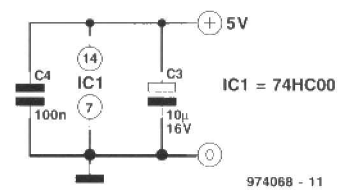
AVM with auxiliary start

Most constructors will have no questions when they have a first look at the diagram. And, indeed, the section based on IC_{1c} and IC_{1d} is a fairly standard astable multivibrator (AVM).

However, the special aspect of the design is the addition of feedback network IC_{1a}-IC_{1b}-D_1. This unusual circuit ensures that the AVM always starts from the same position when the power is switched on. This is, of course, very useful in a number of timer and counter applications.

The feedback network also functions as the start-up circuit. If it were removed, nothing would happen on power-up and both outputs would remain high.





With component values as specified in the diagram, the AVM is arranged for a frequency of 9 kHz.

The circuit draws a current not exceeding 0.15 mA.

[Sorekamp - 974068]

car alarm

Every day a large number of private cars get stolen or broken into. One of the available deterrents against car thieves is a loud car alarm and that is why most new cars are now sold with one fitted as standard. If your car does not already have one, the alarm proposed here may interest you.

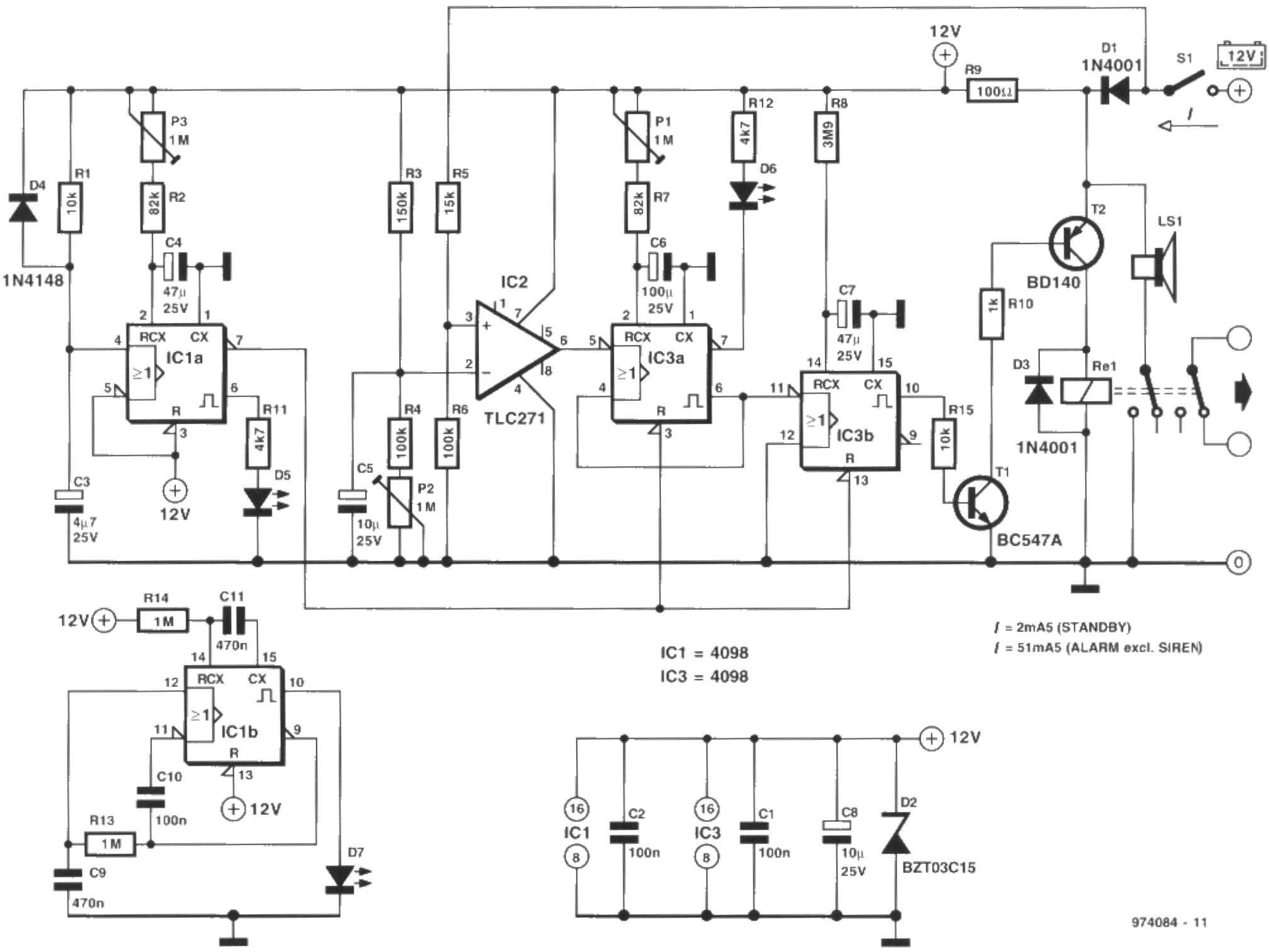
It is a simple yet effective alarm. It is based on the fact that when a car is broken into, at least one of the front doors has to be opened. When that happens, the interior light comes on and this causes a slight temporary drop in the battery voltage. The present circuit detects such a drop and when it does so sounds an alarm.

The circuit consists of a number of distinct sections as shown in the diagram. When S_1 is closed, a trigger pulse, delayed by C_3, is applied to pin 4 of IC_{1a}. When this device has been triggered, its Q output goes high whereupon D_5 lights.

Monostable multivibrators (MMVs) IC_{3a} and IC_{3b} are reset by the low level at the $\overline{Q}$ output of IC_{1a}. When the mono time of the MMVs, which can be set with P_3, has elapsed, the alarm is on. It follows that the driver (and his passengers) must have left the car and closed all doors before this happens.

The voltage drop detector is based on comparator IC_2. This op amp compares the voltages at its two inputs. That at pin 2 is a reference potential whose level is set with P_2. When the battery voltage applied to pin 3 drops, the output of IC_2 becomes low, which triggers IC_{3a}. The level at which the trigger pulse is generated depends, of course, on the setting of P_2.

To enable the driver of the vehicle to gain access without setting off the alarm, there is a delay on opening one of the front doors. This delay is provided by the circuit around IC_{3a}. A trailing edge on pin 5 of IC_{3a} results in a high level at the Q output and a low level at the $\overline{Q}$ output of this device. A yellow LED (D_6) then lights. The time needed to turn off S_1



(and thus disable the alarm) is set with P_1.

If the alarm is not disabled within the preset time, a trailing edge at pin 11 of IC_{3b} will cause the alarm to be sounded for 60 seconds (legally the maximum permissible time). During this period, the starter circuit is disabled, so that the engine cannot be started. After the alarm has ceased sounding, the alarm is on again.

A visual indication of the state of the alarm as shown may be added. When S_1 is closed, IC_{1b} starts to oscillate and a red LED (D_7) begins to flash. [Meers - 974084]

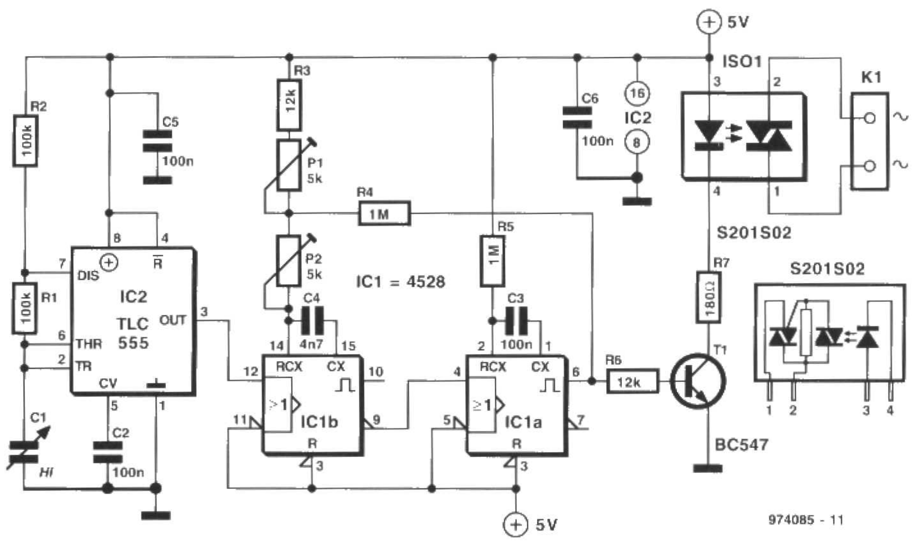
hygrometer

A hygrometer is a device for measuring, or giving an output signal proportional to, ambient humidity. It is, therefore, very suitable for switching on a ventilator or dehumidifier in spaces such as a bathroom or kitchen where the humidity at certain times can reach uncomfortable or unacceptable levels.

Normally, hygrometers use a hygristor as sensor, but the present circuit uses a capacitor whose capacitance is dependent on the degree of humidity.

With values as specified in the diagram, the frequency of the output signal of oscillator IC_2 varies from 30 kHz in dry conditions to 25 kHz when the ambient humidity is 100%.

The output of the oscillator is applied to retriggerable monostable multivibrator (MMV) IC_{1b}, whose Q



output remains high as long as the oscillator frequency is high.

When the humidity rises, the oscillator frequency drops and short pulses appear at the Q output of IC_{1b}. These trigger MMV IC_{1a}, whose output then goes high, whereupon the electro-optical relay trips. Resistor R_4 provides some hysteresis to prevent relay clatter.

The humidity at which the relay should trip is set with P_1. The desired hysteresis is set with P_2.

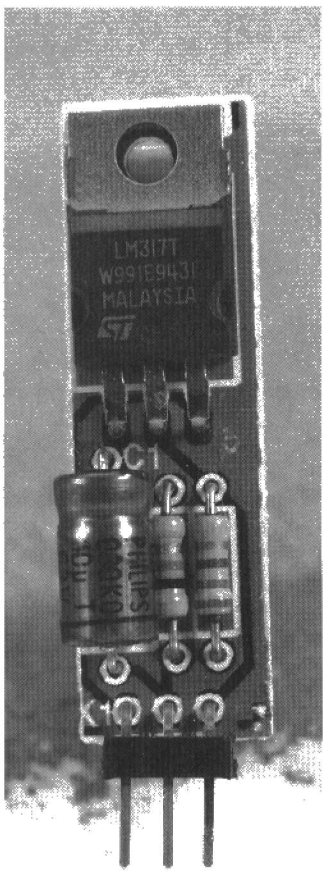
The mono time of IC_{1a} is set to 30 ms, which is more than ample to switch on T_1.

The electro-optical relay is a Type S201S02 from Sharp, which can switch loads up to 1 A.

The circuit draws a current of about 25 mA.

(Lucassen - 974085)

78xx replacement



The circuit shown in the diagram may prove useful when a 78xx voltage regulator needs to be replaced by a better quality type for which there is not enough space. It may also prove useful when a slightly different voltage is required.

The replacement circuit is based on a Type LM317 regulator from National Semiconductor. The IC and the three requisite external components are fitted on a tiny PCB whose terminals coincide with those of the terminals of a 78xx device. In other words, the board fits exactly where the 78xx used to be – it is, however, slightly higher.

The LM317 offers three advantages over a 78xx: (a) the ripple suppression is better; (b) the input voltage range is larger; (c) the output voltage can be arranged at any desired value with the aid of two standard resistors.

The resistors are calculated by

$$U_o = U_{REF}(1 + R_2/R_1).$$

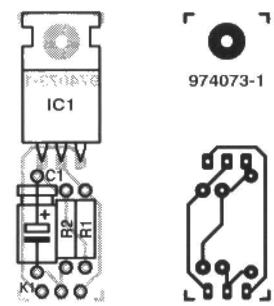
In case of the LM317, U_{REF} is 1.25 V. The values of R_1 and R_2 must be such that the output current does not drop below 3.5 mA. With values as specified in the diagram, the output voltage is 15.3 V and the quiescent current is 4.6 mA.

Parts list:

Resistors (U_o = 15.3 V):
R_1 = 270 Ω
R_2 = 3.0 kΩ

Capacitors
C_1 = 10 µF, 63 V

Integrated circuits:
IC_1 = LM317
(or LM350 - see text)

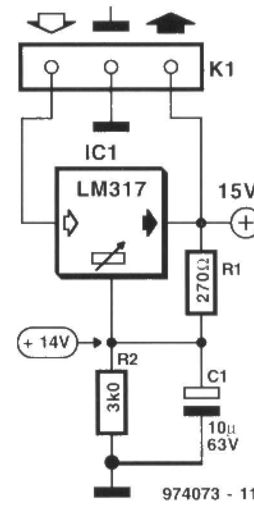


The LM317 can provide output currents of up to 1.5 A. If a larger current is required, the pin-compatible Type LM350 may be used, which can provide currents of up to 3 A. Bear in mind, however, that the board is not designed for continuous currents of 3 A.

In either case, it may be necessary, depending on the dissipation, to mount the IC on a small heat sink.

Although not shown in the diagram, the IC needs decoupling capacitors of ≥ 100 nF at the input and 1 µF at the output. Since these are also required for the 78xx, it is assumed that these capacitors are already present.

(Giesberts - 974073)



S/PDIF-to-AES/EBU converter

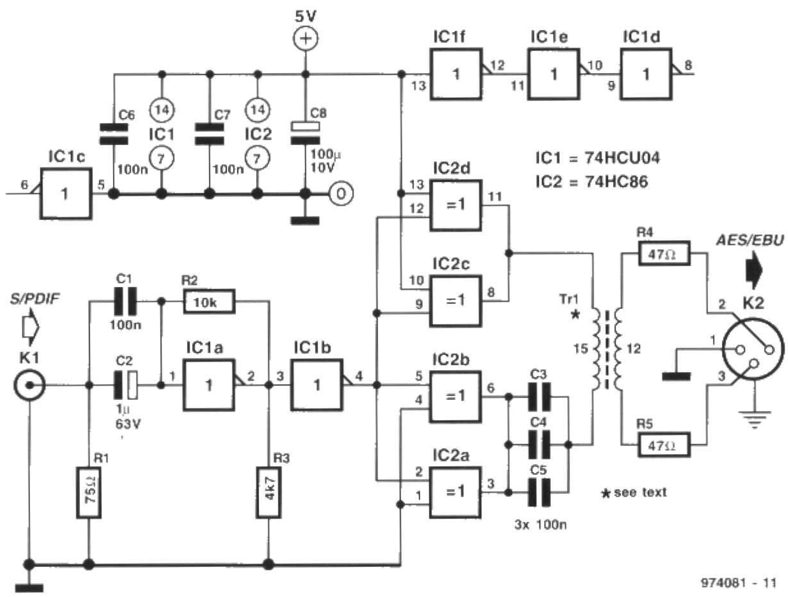
This magazine assumes that most readers use consumer appliances. However, in the case of the sample rate converter (October 1996), many readers have asked for a conversion from the asymmetrical S/PDIF format to the symmetrical (professional) AES/ EBU format and such a converter is presented here.

The timing and levels comply with the AES3-1992 Standard. This means that: (a) the output voltage must be 2-7 V_{pp} (transmitter load 100 Ω); (b) the rise and decay times must be 5–30 ns; (c) the output impedance must be 110 Ω ±20% (within the bandwidth of 0.1–6 MHz). These requirements are met in the design in the diagram (30 ns; 3.6 V_{pp}; 115 Ω respectively).

The circuit at the input, based on IC_1, converts the S/PDIF signal to HC levels. Op amp IC_{1a} is an analogue amplifier, while IC_{1b} raises the signal to the level of the supply lines. Resistor R_3 pulls IC_{1a} slightly from its centre of operation, so that the output buffer attains a logic level even in the absence of an input signal.

The buffer to drive the output transformer is formed by a symmetrical circuit based on IC_{2a}–IC_{2d}. This arrangement ensures that the rise and decay times are equal and that the output voltage is large enough. The use of XOR gates ensures that the transfer times for inverting and non-inverting of the output of IC_{1b} are equal. Since the primary transformer voltage is 9.5 V, the secondary voltage could be decreased slightly. This is beneficial for the linearity of the impedance and the bandwidth of the converter.

The transformer is wound on a Type G2-3/FT12 core: the primary on one side and the secondary on the other. Both windings consist of enamelled copper wire of 0.5 mm dia. The core can accommodate a tin-plate screen for maximum common-mode suppression. Regulations



require this to be ≥ –30 dB w.r.t. the nominal output level; in the present circuit it is –48 dB (with screen).

The output impedance, ignoring R_4 and R_5, is about 22 Ω. If a figure of exactly 110 Ω is wanted, R_4 and R_5 should have a value of 44.2 Ω.

Capacitors C_3–C_5 prevent any direct current flowing through the transformer in the absence of a signal as this would short-circuit IC_2. The use of three capacitors in parallel ensures that the impedance and loss resistance of them (ceramic, high-stability types) are low.

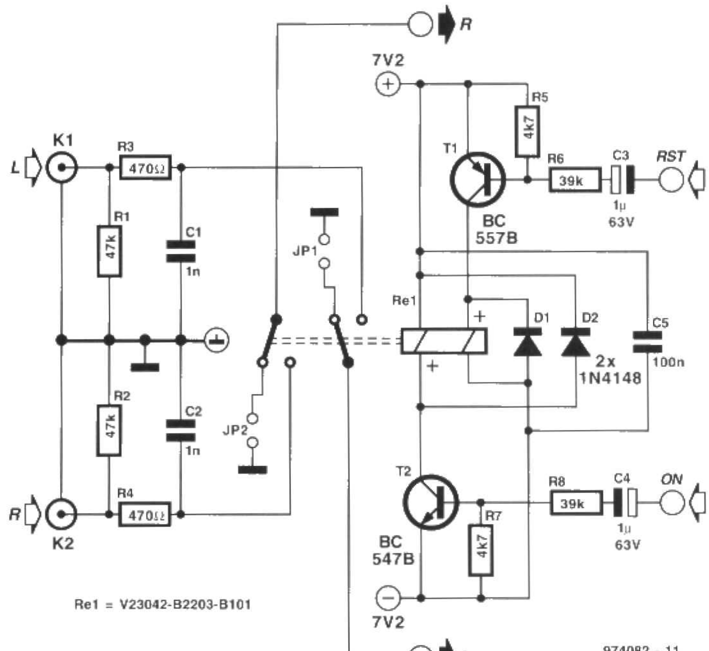
The AES/EBU signal is output via XLR connectors (to IEC268-12). Note that versions with male pins and female shells are used. Pin 1 is for the screen or the signal earth; pins 2 and 3 are for the signals – the phase is not important.

The circuit requires a 5 V power supply from which a current of about 26 mA is drawn.

If the converter is used with the sample rate converter published in the October 1996 issue or the 20-bit analogue-to-digital converter in the December 1996 issue, do not forget to use the CS8402A in the professional mode.

[Giesberts - 974081]

AF input module



When it comes to input selection in a preamplifier, the use of a relay is always better than a simple rotary switch – at least from a quality point of view. A relay obviates long signal paths to a common switch and may be controlled electronically. In the module a bistable relay is used since a standard relay needs a continuous energizing current. It was felt that the slightly higher price of a bistable relay would be more than compensated by the high current requirement of the standard relay.

The present module, which is intended primarily for use with the battery operated preamplifier (January 1997 issue), but may of course be used with other preamplifiers, serves one (stereo) input. This means that there are at least six of these modules required to replace the existing input selector in the battery operated preamplifier.

The drive to inputs RST and ON is best obtained from the 'AF input selection' article elsewhere in this issue.

The two relays are energized by transistors T_1 and T_2. These provide a pulse of a few milliseconds, since the base drive is effected via a differentiating network. Current only flows through the relay coils when the charging current for C_3 or C_4 is sufficient to bring the base-emitter junction of the relevant transistor into conduction.

Transistor T_1 is switched on when RST changes from high to low and T_2 when ON goes from low to high. Resistors R_5 and R_7 ensure that when C_3 or C_4 is being discharged the maximum permissible reverse bias voltage of the relevant transistor is not exceeded, and also that the switching pulse is well defined.

Diodes D_1 and D_2 short-circuit any voltage peaks caused by the relay inductances when T_1 or T_2 switch off and thus protect the transistors.

Resistors R_1 and R_2 at the inputs are terminating resistors.

Networks R_3-C_1 and R_4-C_2 filter out any r.f. noise.

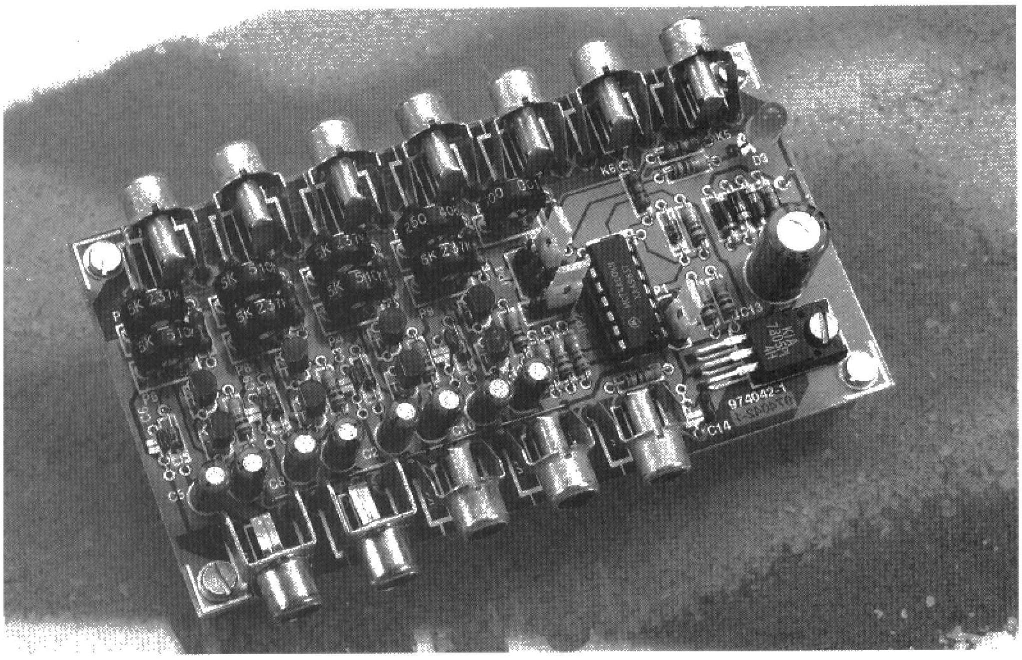
Each of the relay contacts is complemented with a jumper to earth. Use of these jumpers depends on the application, but even then only if the amplifier is a summing type. Non-selected inputs are then linked to earth and any crosstalk is suppressed effectively. Therefore, if the amplifier is a buffer, as in the battery operated preamplifier, the jumpers should be left open.

Mind the correct polarity (shown on the relay) when connecting the relays, because incorrect polarity means that the relay action is reversed. The marking on some relays is by bullets and in others by plus signs. The bullets give the polarity for the same function (for instance, positive for the make contact), and the plus signs the polarity of the function of the relevant coil. There is, therefore, no difference in pinout (function).

The relays are 12 V types with 720 Ω coils.

[Giesberts - 974082]

RGB video amplifier

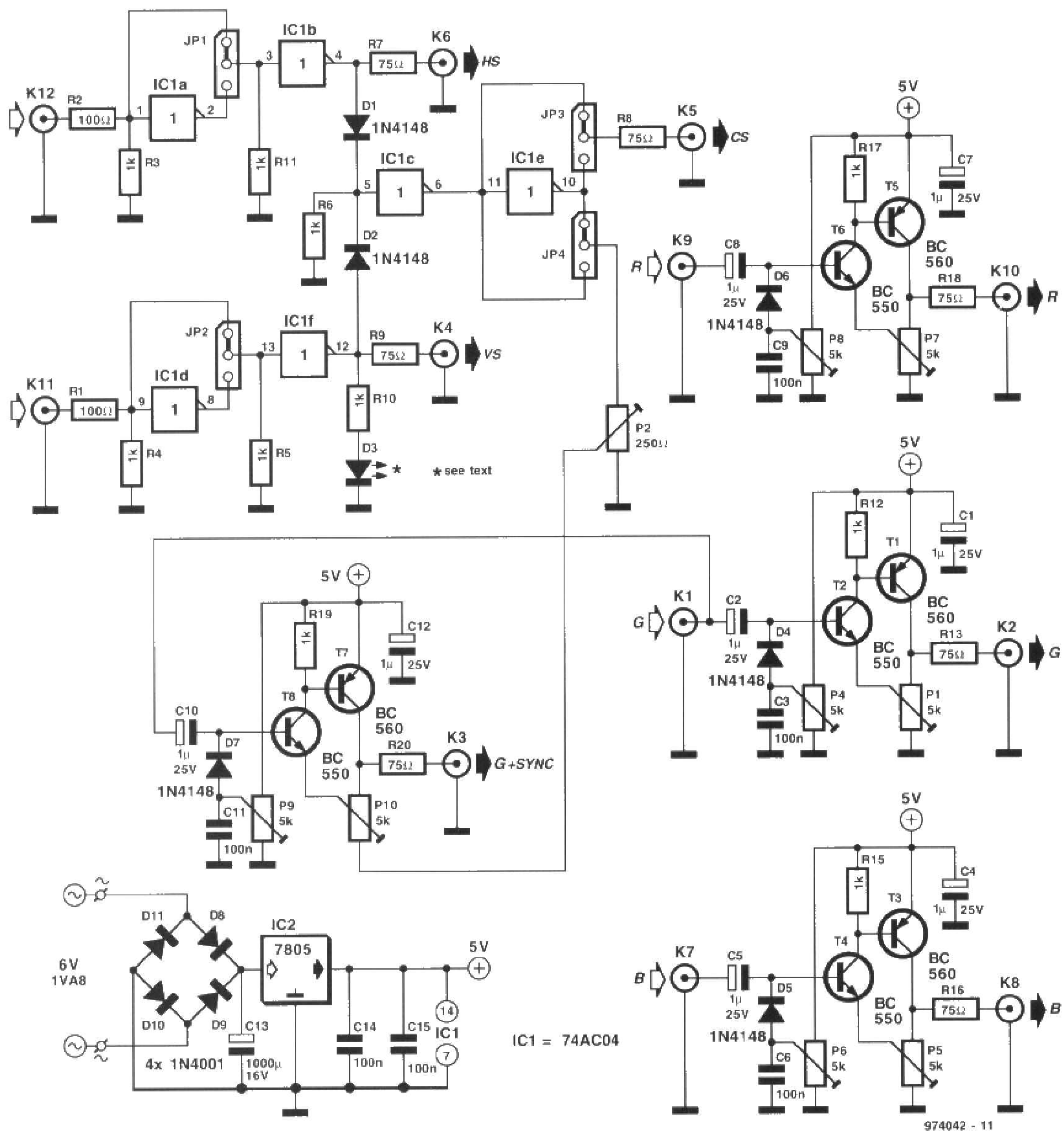


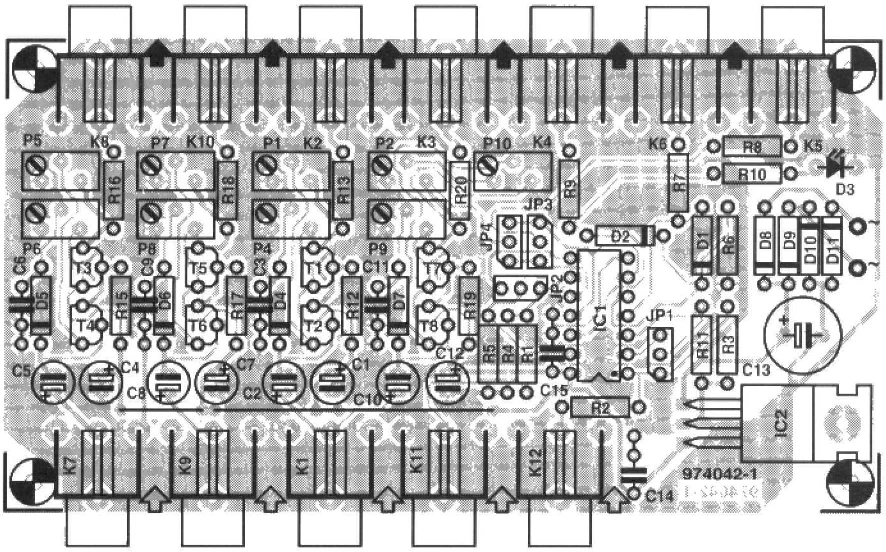
This amplifier board is aimed at those of you who want to experiment with RGB video connections between a PC and VGA monitor. Many up-market VGA monitors available today have separate RGB V/Hsync inputs besides the perhaps more familiar 15-way high-density sub-D input for a single cable connection to the VGA card.

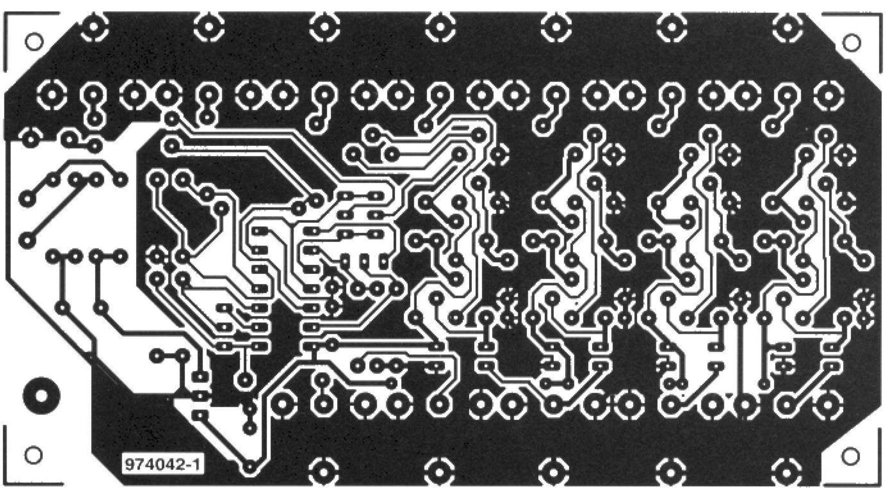
This circuit makes use of the solution with the better quality: separate (coax) RGB connections.

The two-transistor RGB (red, green, blue) amplifiers are identical, each containing adjustment points for the black (reference) level and the signal level. In the R(ed) amplifier, for example, the respective controls are presets P8 and P7.

Another, similar, amplifier, T8-T7, supplies a combined (G+CSYNC) signal. The CSYNC portion of this







COMPONENTS LIST

Resistors:
R1,R2 = 100Ω
R3-R6,R10,R11,R12,R15, R17,R19 = 1kΩ
R7,R8,R9,R13,R16,R18, R20 = 75Ω
P1,P4-P9 = 5kΩ multiturn vertical
P2 = 250Ω multiturn vertical
P10 = 500Ω multiturn vertical

Capacitors:
C1,C2,C4,C5,C7,C8,C10,C12 = 1µF 25V radial
C3,C6,C9,C11,C14,C15 = 100nF
C13 = 1000µF 16V radial

Semiconductors:
D1,D2,D4-D7 = 1N4148
D3 = LED
D8-D11 = 1N4001
T1,T3,T5,T7 = BC560C
T2,T4,T6,T8 = BC550C
IC1 = 74AC04
IC2 = 7805

Miscellaneous:
JP1-JP4 = 3-way jumper
K1-K12 = cinch socket, PCB mount
Printed circuit board, order code 974042-1 (see Readers Services page)

signal is adjusted to individual requirements using preset P2.

The RGB and (G+CSYNC) amplifiers have 75-Ω output resistors to ensure a good match to coax cable. Their drive capacity is such that relatively long coax cables may be used without running into bandwidth reduction problems. Do not go over 3 metres, however.

Jumpers JP1 and JP2 enable the HS (horizontal sync) and VS (vertical sync) signals to be output in inverted or true form as required by the monitor (RTFM). The VS and HS signals are also combined by diodes D1 and D2 to create a composite sync (CS) signal. This, too, is available in true and inverted form on socket K5, the polarity selection being made with jumper JP3. The output impedance of the CSYNC output is 75 Ω. The intensity of LED D3 indicates the polarity of the VS signal: bright means negative VS; weak means positive VS. Jumper JP4, finally, selects between true or inverted CSYNC for use in the (G+CSYNC) adder, T7-T8.

The amplifier board has its own power supply consisting of four 1N4001's (D8-D11), a smoothing capacitor (C13) and the customary voltage regulator (IC2). The board may be powered by a small 6-volt mains transformer.

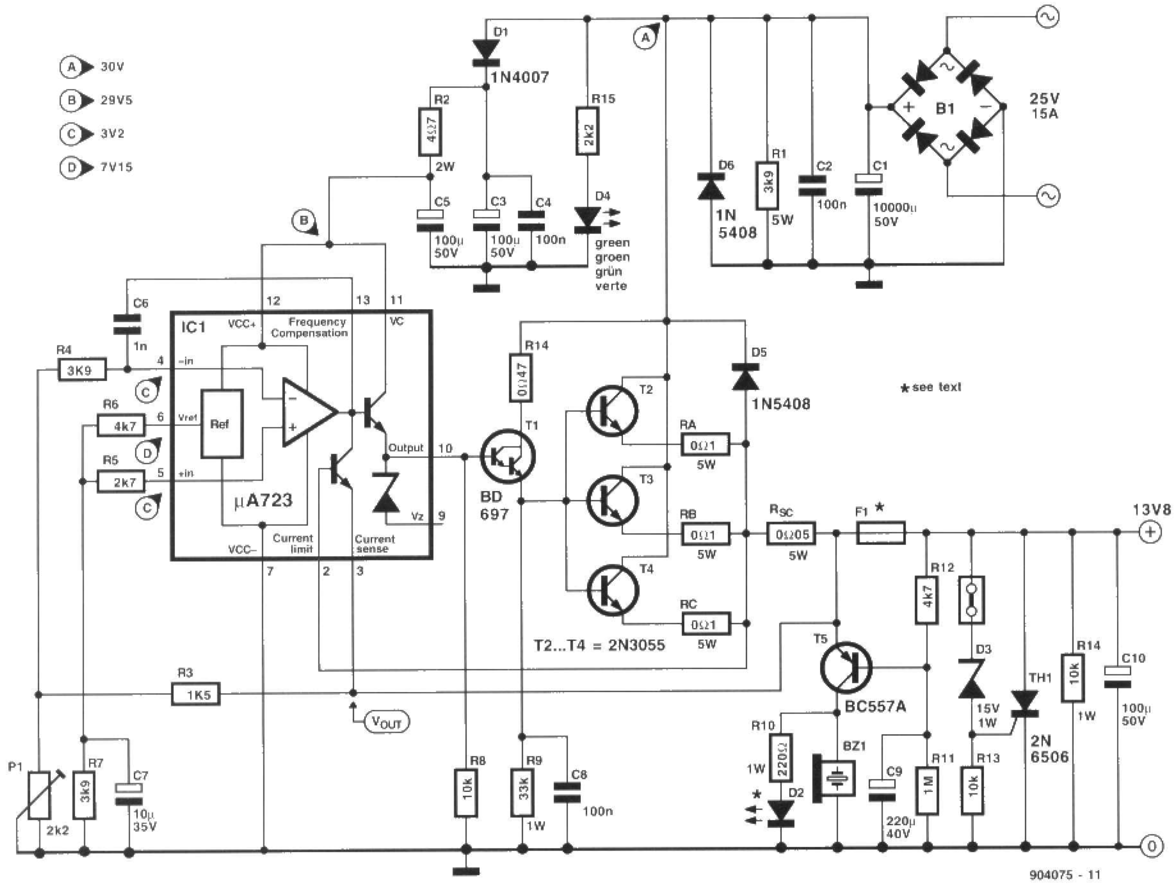
(974042 - W. Foede)

13.8-V power supply for mobile rigs

At the heart of this power supply is the type 723 voltage regulator. Despite its age, the 723 is still popular among radio amateurs because it is reliable, widely available and far cheaper than many of the latest high-power (>1.5-A) three-terminal voltage regulators, even if you add the cost of two or three 2N3055-like current booster transistors (which many of you will be able to raise from junkbox). The 723 comes in two flavours, a 14-pin DIL case or a 10-lead metal can. The type number may also be disguised: basically, look for LM723 or µA723. The pin numbers shown here refer to the 14-pin DIL case.

This supply is intended for home use of mobile ham radio transceivers. As many of today's combined 2m/70cm FM mobile rigs are capable of supplying more than 50 watts of RF power, a pretty heavy PSU is required if such a radio is not run off a vehicle battery. The PSU shown here has the answer because it is capable of delivering up to 12 A at 13.8 V in the configuration shown here.

The 723, IC1, is conventionally wired, driving a power transistor array and monitoring the supply output current by measuring the voltage drop across series resistor R_{SC}. The nominal supply output voltage of 13.8 V is set with preset P1. The raw input voltage of the supply is obtained from a 22 to 25 V, 15 A transformer, a 25 A bridge rectifier



904075 - 11

and a 10,000 μF smoothing capacitor.

The current booster consists of a BD679 (or BDV65C) darlington transistor and three parallel connected 2N3055's (or 2N3773's) with emitter current distributing resistors, R_A, R_B and R_C.

The current sense resistor for the short-circuit protection, R_{SC}, has a value of 0.05 Ω which results in a protection onset level of about 0.6 V/0.05 = 12 A. This resistor is either made from resistance wire or from two parallel-connected 0.1 Ω/5 W resistors.

A 12 A or 16 A fuse is inserted in the positive output rail as an additional protection against output short-circuits. If the fuse blows, transistor T5 briefly actuates an active buzzer and a flashing LED. It can do so by draining the charge built up in C9.

The 15-volt overvoltage protection at the output of the supply is a so-called crowbar circuit. If the supply is set to an output voltage other than 13.8 V, the zener diode, thyristor and associated resistor have to be omitted, or disconnected by breaking the wire link indicated in the circuit diagram. If used, the thyristor should have a current rating of about 25 A. Here, a type 2N6506 is recommended.

The darlington and power transistors have to mounted on a **large** heat-sink using insulating washers. The author uses a small 12-V fan to assist in the cooling of the heat-sink. This fan is readily powered by the supply: simply use two or three diodes in series to drop the operating voltage to about 12 V.

As the choice of components used in the supply is far from critical, the circuit is easily modified for smaller output currents and/or different output voltages. Using a 10-amp transformer and two 2N3773's, for example, is okay if you want an 8-A PSU. Similarly, a 5-amp transformer and one power transistor are perfect for a 4-A version of the PSU.

(974075 - V.S. Harisankar VU3NSH)

four-state flip-flop

Flip-flops (US English) or bistables (British English) are well-known and widely used building blocks performing control, register, memory and toggle functions in logic circuits. The most popular ones are probably the CMOS 4013 (dual D type), the 4027 (dual J-K type), and the TTL 7474 (dual-D type). The latter also comes in LS-TTL, HC and HCT versions. Although D, J-K and S-R bistables have slightly different truth tables, they all share a common characteristic: they have two stable states.

The circuit shown here is intended for applications where four instead than just two logic states are required. The 4028 CMOS BCD-to-decimal decoder at the heart of the circuit has four binary inputs and ten decimal outputs. Any allowed BCD input combination (0000 through 1001) will set the corresponding output to logic '1'. Each of the remaining six input combinations (1010 through 1111) resets all of the decoder outputs to '0'. In this application, only combinations are used which contain one logic '1' and three logic '0's, that is, 0001, 0010, 0100 and 1000. These activate decoder outputs 1, 2, 4 and 8 respectively, to which a kind of feedback is applied by means of diodes D2-D5. Assuming that decoder output 1 is set to logic '1', then this state is transferred to input 2^0 (1) via diode D2, while the other three inputs remain at '0' because of resistors R2, R3 and R4. This state remains stable until one of the push-buttons is pressed. S2, for example, then sets a '1' at the 2^1 (2) input of the decoder, which responds by resetting output 1 (as well as input 2^0), and then activate output 2. This state is 'latched' by diode D3, which starts to conduct as soon as S2 is released.

Components C1, R5 and D1 produce a short positive pulse at power-on, thus defining decoder state 1 as the initial state of the circuit.

The inverters in IC2 act as current boosters to enable the decoder to control four LEDs which flag the state of the 'fourstable'. Based on

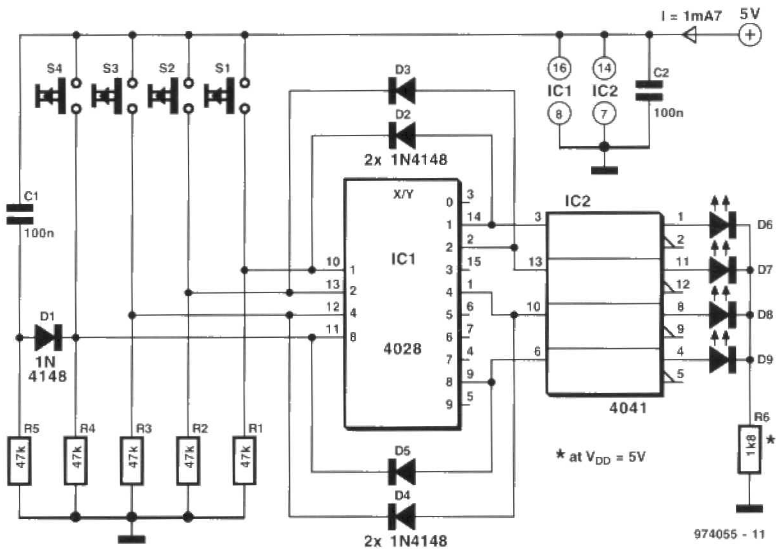
standard CMOS circuits, the circuit may, in principle, be run off any supply voltage between 3 V and 18 V. However, the indicated value of R6 is for a 5-volt supply. With different supply voltages, the value should be recalculated from

R6 = $(U_b - 2)/I$

where I is the LED current in mA, while the value of R6 is in kilo-ohms.

Although it is tempting to simplify the circuit by omitting the LED driver and substituting LEDs for D2, D3, D4 and D5, you should be weary about making such a modification because the 4028 you are using may not be able to source the required current. The widely used HCF-type CMOS ICs from Thomson, for example, can not supply more than about 2.6 mA (typ.) without degradation of the output voltage level, if the supply voltage is higher than 10 V. The solution is to apply high-efficiency (low-current) LEDs, and lower the value of resistors R1 through R4 to 4.7 kΩ for a 10-V supply, or about 10 kΩ for an 18 V supply. Also, C1 should then be increased to 1 μF. Remember, though, that these changes will only work if the supply voltage is higher than 10 V.

(974055 - V. Mitrovic)



mains-THD meter

The circuit described, in conjunction with a digital voltmeter (DVM), may be used to measure the total harmonic distortion (THD) of the mains supply voltage. A knowledge of this may be useful when the effect of switch-mode supplies or dimmers on the mains supply is to be determined. This is important, because the same mains supply is used to power, say, an audio system of which low distortion is expected.

The 230 V mains voltage is divided symmetrically by 230 by R_1–R_5. This means that the potential difference, pd, across R_5 is 1 V. The divider is symmetrical to prevent potentially dangerous voltages at the output terminals.

There follows a notch filter with a centre frequency of 50 Hz. Provided the filter is set up properly, the mains frequency is attenuated by 70 dB. This means that the only frequencies that can appear at the output of the circuit are harmonics of the mains frequency.

Circuit values are such that every 1 mV r.m.s. measured by the DVM at the output corresponds to 0.1% THD.

Calibrate the circuit as follows. Set P_1, P_2 and P_3 to the centre of their travel and, **taking great care**, apply the mains voltage to the input terminals.

Adjust P_1 for the lowest possible reading on the DVM. Note the position of this preset and then set it exactly between this and the centre position.

Next, adjust P_3 for the lowest possible reading on the DVM.

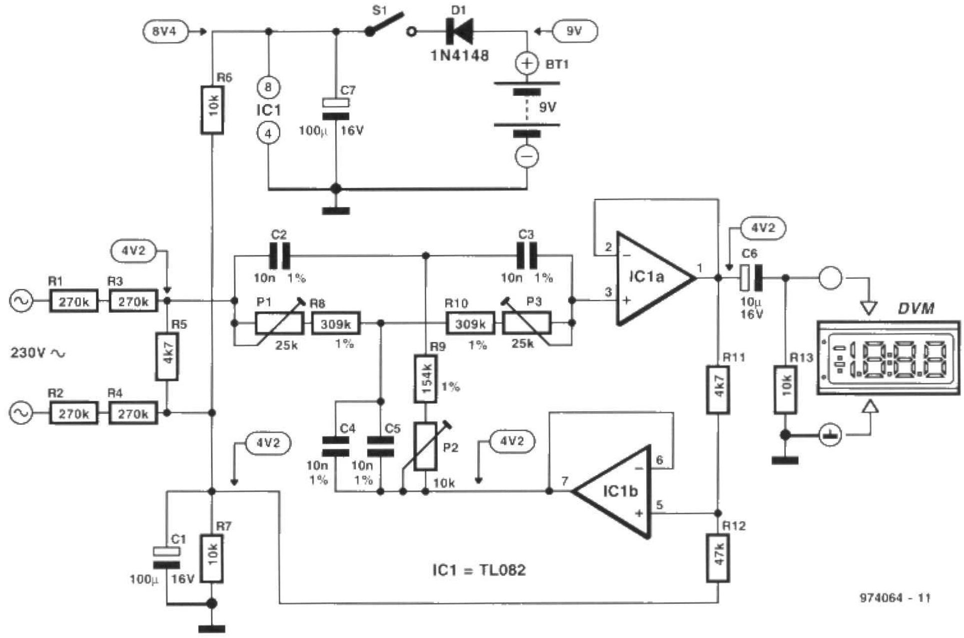
Then, alternately adjust P_1 and P_3 for a minimum reading on the DVM.

When this has been established, adjust P_2 for the lowest possible reading on the DVM.

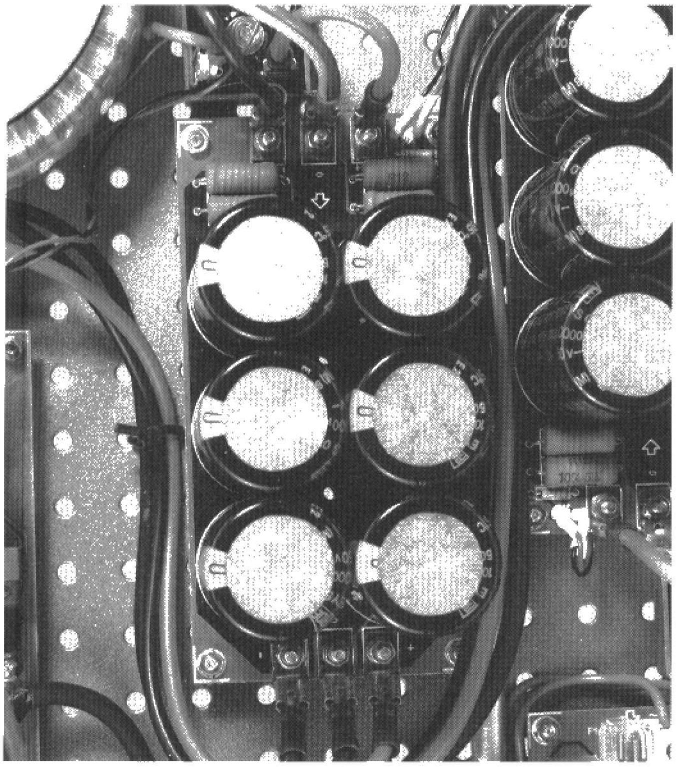
Since the circuit draws a current of only 5 mA, power may be obtained from a 9-V alkaline or rechargeable battery.

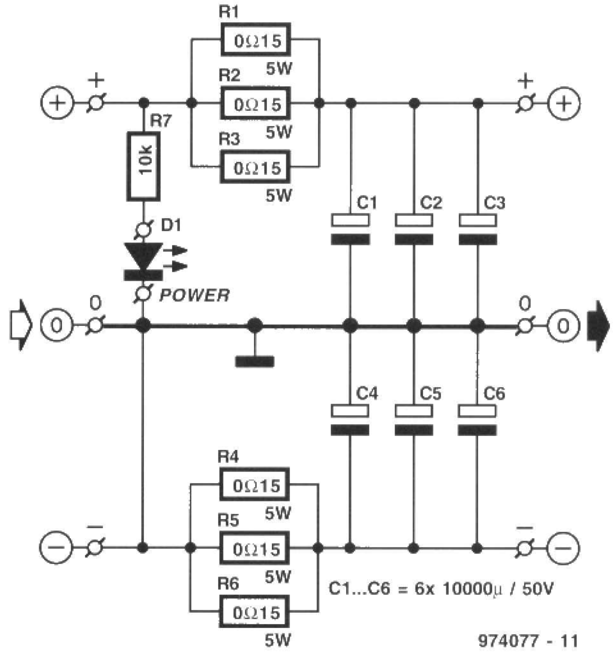
In the construction of the meter, make absolutely certain that all mains-carrying part are well insulated.

(Bonekamp 974064)



supply board for output amplifiers

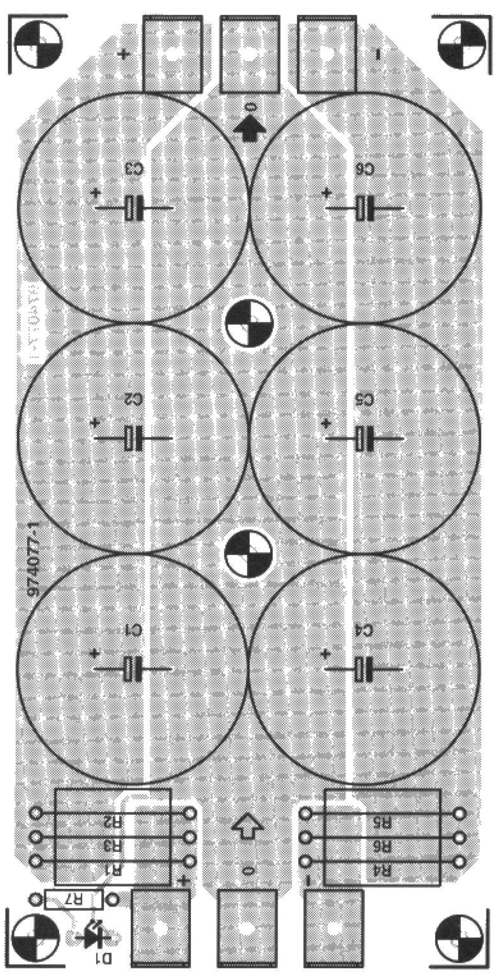


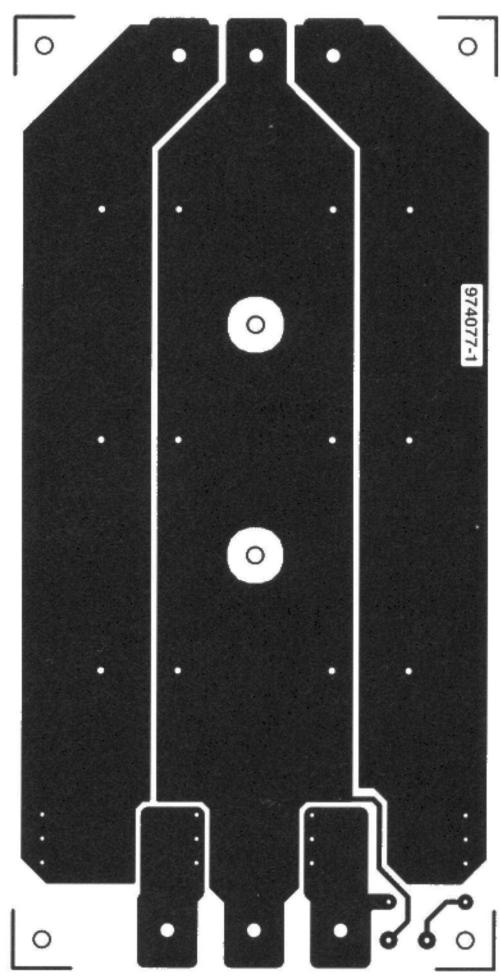


Apart from their electronic configuration, all output amplifiers comprise the same elements: an amplifier board, a mains transformer, a bridge rectifier, and electrolytic smoothing capacitors. The board is normally screwed to the heat sink, while the transformer and bridge rectifier are fixed to the bottom of the enclosure. Often, there is no such defined location for the electrolytic capacitors. These are mounted on a piece of prototyping board, or to the bottom of the enclosure with suitable brackets, or …

Since this is a recurring difficulty, many constructors will be pleased with the board design shown here. Its layout is such that it is suitable for use with almost any type of output amplifier operating from a symmetrical power supply.

The board can accommodate six electrolytic capacitors with a value of up to 10,000 μF and a rating of 50 V. They are assumed to have a pitch of





Parts list

Resistors:
R_1–R_6 = 0.15 Ω, 5 W
R_7 = 10 kΩ

Capacitors:
C_1–C_6 = 10,000 μF, 50 V, pitch 10 mm, max. dia. 30 mm

Semiconductors:
D_1 = LED, high efficiency

Miscellaneous:
6 off single-pole PCB terminal block

10 mm and a maximum diameter of 30 mm.

The board also has space for 'soft switch-on' resistors with a value of 0.15 Ω and rated at 5 W. These resistors damp the peaks in charging current and also aid in smoothing spurious current peaks on the supply voltage.

Finally, the board has an on/off indicator in the shape of a high-efficiency LED and requisite series resistor.

Connections to the board are via single-pole PCB terminal blocks, which guarantee good contacts and can handle large currents.

[Giesbers - 974077]

light-operated squeaker

The Type TSL230 IC is a programmable light-to-frequency converter. It is a single-chip combination of a silicon photodiode and a current-to-frequency converter, housed in an 8-pin DIL case.

The IC provides a rectangular-wave signal whose frequency depends on the strength of the incident light. The sensitivity may be set in one of three ranges via pins 1 and 2. The divisor of the output frequency may be set in one of four ranges via pins 7 and 8—see Table.

The IC needs an asymmetric power supply of only 2.7 V.

Although the IC is primarily intended for use in measuring instruments, in the present circuit it is used as a light-dependent squeaker. All this needs is the addition of a small push-pull amplifier and a tiny loudspeaker.

The amount of incident light determines the frequency emanated by the loudspeaker. So, if the incident light is made to vary, the reproduced sound varies. It is not known whether a melody can be generated!

The sensitivity and divisor of the output frequency are set with quad DIP switch S_2. If the four switches are called S_{2a}–S_{2d} from top to bottom, the following functions are obtained.

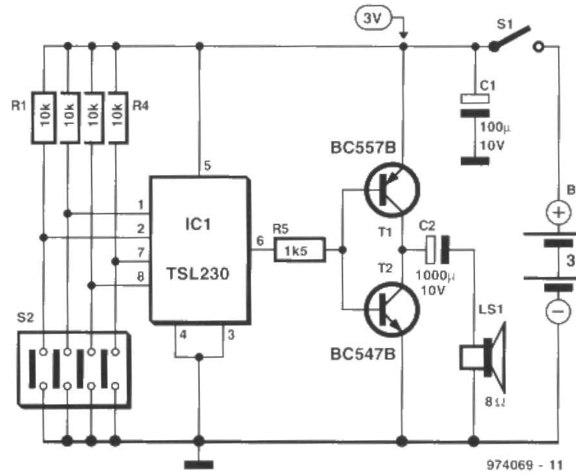
S_{2a}	S_{2b}	*Sensitivity*
0	0	power down
0	1	×1
1	0	×10
1	1	×100

S_{2c}	S_{2d}	*Divisor*
0	0	1
0	1	2
1	0	10
1	1	100

As usual, a 1 represents an open switch and a 0 a closed one.

Depending on the ambient light, some experimenting with the switches may (will) be necessary before the output frequency falls within the audible range.

Power-down is a kind of standby position in which the IC draws a current of only 10 μA. In normal operation, the current does not exceed 10 mA. Power may therefore be obtained from two AA alkaline batteries.



[Bonekamp - 974069]

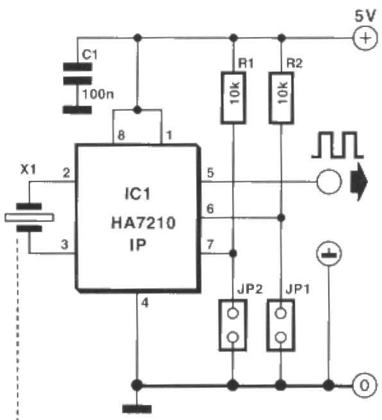
low-power crystal oscillator

The Type HA7210 IC from Harris Semiconductor is an integrated low-power crystal oscillator that can be programmed externally to generate output frequencies between 10 kHz and 10 MHz.

The oscillator is a Pierce type that is arranged to draw as small a current as possible. Only a decoupling capacitor, a crystal and frequency-determining components are required externally.

The circuit is highly stable over a wide range of supply voltages and a wide temperature range.

The application shown in the diagram is a basic circuit suitable for frequencies between 10 kHz and 10 MHz. The position of jumpers JP_1 and JP_2 depends on the chosen crystal frequency. In the table a '1' indicates that the jumper is left open and a '0' that the jumper must be placed.



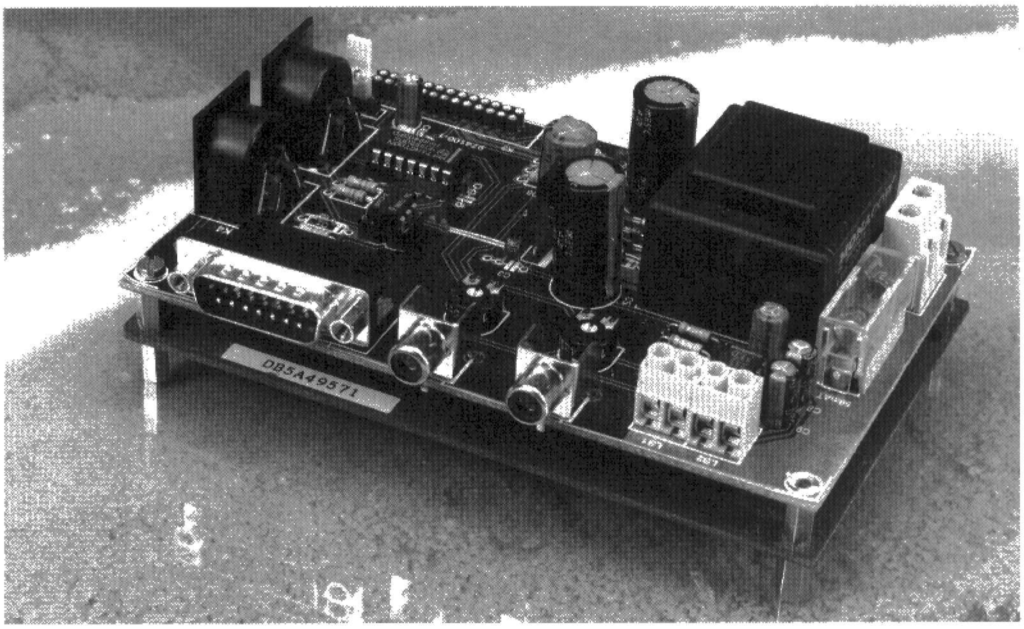
X1	JP2	JP1
10kHz – 100kHz	1	1
100kHz – 1MHz	0	1
1MHz – 5MHz	1	0
5MHz – 10MHz	0	0

The crystal must be cut for parallel resonance. In the present application, the load capacitance is 7.5 pF for the bottom range and 2.5 pF for the other ranges. If this does not suffice for the relevant crystal, ceramic capacitors of twice the value of the specified load capacitance must be placed between pin 2 and earth and between pin 3 and earth.

The oscillator draws a current of 0.5 mA in the bottom range and 7 mA at 10 MHz.

[Bonekamp 974045]

Yamaha DB50XG stand alone soundcard



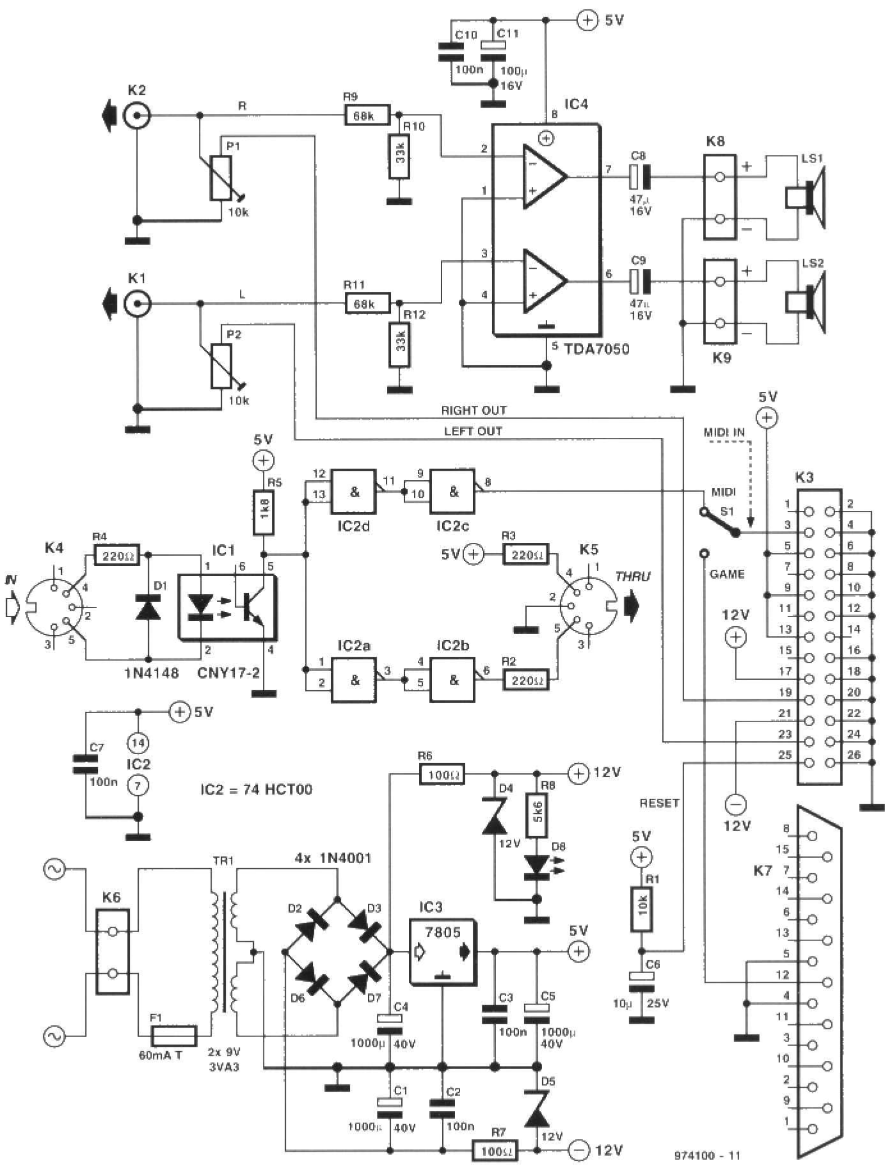
There are a number of daughter boards that can be added to SoundBlaster (clone) cards to produce a much better sound than the internal FM chip. One of these is the Yamaha DB50XG sound card, which is relatively cheap and widely available. Those of you who would like to use this card but do not have a suitable sound card for the PC, the DB50XG can be used as a stand-alone sound card with superb MIDI wavetable sound quality, simply by adding some hardware and a suitable power supply as shown here. The additional hardware allows the DB50XG to be driven by any MIDI source, whether computer or musical keyboard.

The great thing about the DB50XG is that it offers vastly improved sound quality over OPL and similar FM synthesizers which are used on low-cost soundcards to imitate MIDI wave samples. Thanks to the 18-bit DACs used on the DB50XG, the board even surpasses soundcards that do have an internal MIDI wavetable.

The circuit diagram shows that MIDI signals arrive via a standard 5-way DIN socket, J4. Next, an opto-isolator, IC1, converts the MIDI 5 mA current loop into a TTL compatible signal which is fed to the MIDI THRU connector, K5, via Schmitt trigger NAND gates IC2a and IC2b. It is also fed to the MIDI IN terminal of the DB50XG via IC2d, IC2c, switch S1 and socket K3. The stereo sound signals returned by the DB50XG are taken from the same socket and fed to a small on-board power amplifier, IC4. The signals are also available to active loudspeakers via cinch sockets K2 and K3. Presets P1 and P2 are used to set the sound volume.

Many soundcards not having a wave-blaster extension connector supply a MIDI output signal via the gameport connector. To avoid wasting money on (generally expensive) adapters offered by the soundcard manufacturer, the host board discussed here has a direct input for a 15-way cable attached to the gameport. If this input is used, S1 should be set to the 'GAME' position. The combination R5-C1 provides a reset pulse for the DB50XG at switch on.

The power supply is totally traditional, providing ±12 V and + 5 V. Note that a 3.3-VA centre-tapped 9-0-9 volt transformer is used.



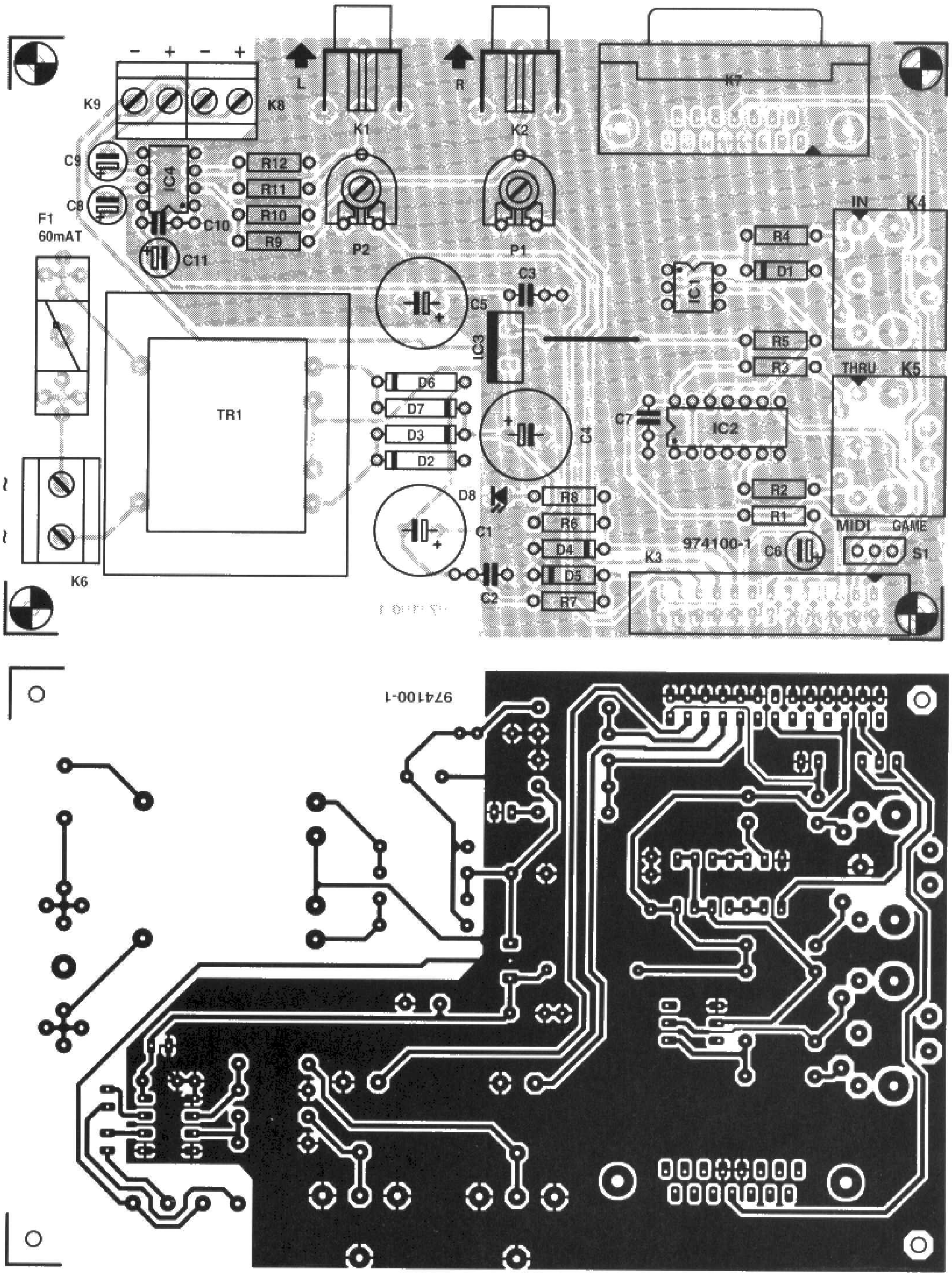
COMPONENTS LIST

Resistors:
R1 = 10kΩ
R2,R3,R4 = 220Ω
R5 = 1kΩ8
R6,R7 = 100Ω
R8 = 5kΩ6
R9,R11 = 68kΩ
R10,R12 = 33kΩ
P1,P2 = 10kΩ preset H

Capacitors:
C1,C4,C5 = 1000µF 40V radial
C2,C3,C7,C10 = 100nF
C6 = 10µF 25V radial
C8,C9 = 47µF 16V radial
C11 = 100µF 16V radial

Semiconductors:
D1 = 1N4148
D2,D3,D6,D7 = 1N4001
D4,D5 = zener 12V
D8 = LED
IC1 = CNY17-2
IC2 = 74HCT00
IC3 = 7805
IC4 = TDA7050

Miscellaneous:
K1,K2 = cinch socket, PCB mount
K3 = 26-pin connector (DIY, see text)
K4,K5 = 5-pin DIN socket, 180°, PCB mount
K6 = 2-way PCB terminal block, pitch 7.5mm
K7 = 15-way sub-D plug, angled pins, PCB mount
K8,K9 = 2-way PCB terminal block, pitch 5mm
S1 = 3-way jumper or single-pole changeover switch
TR1 = 2x9V 3VA3 (Monacor/Monarch VTR3209)
F1 = fuse 60mAT with PCB holder
Yamaha daughter board DB50XG
PCB, order code 974100-1 (see Readers Services page)



The printed circuit board shown here has exactly the same size as the DB50XG. As shown in the photograph, the two boards are secured in sandwich fashion using four PCB spacers mounted in the corners. Although a 26-way pinheader or boxheader shape is indicated on the host board component overlay, 26 pieces of solid, bare wire (carefully soldered, aligned and cut to length) will also fit directly in the DB50XG waveblaster socket.

Finally, lots of useful information on the DB50XG is available on the Internet. Just to mention two links:
http://www.yamaha.co.uk
http://www.castrop-rauxel.netsurf.de/homepages/michael.banz
The official Yamaha site is good for background information on the XG standard. The latter web site contains an FAQ list which is useful for anyone having a DB50XG, or considering the purchase of one, as it contains much information on setting up with SoundBlaster cards.

(974100 T Scarff)

active Bessel filter

A Bessel filter is typified by the complete absence of any ringing. On the other hand, its frequency characteristic is less steep around the cut-off point than that of a Butterworth section.

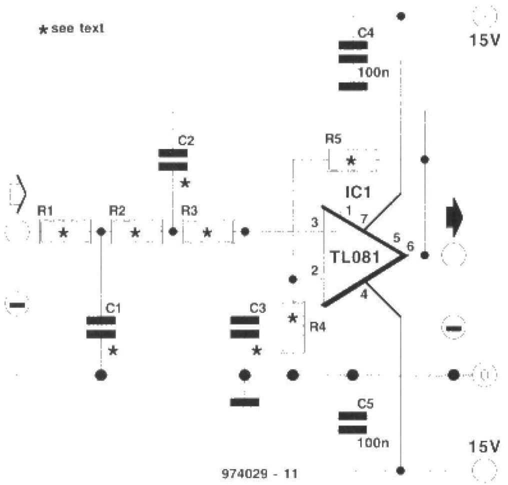
The table in the diagram gives six different values for R_4 and R_5 resulting in varying amplification factors. Since the amplification has a direct influence on the filter response, the values of several frequency-determin-

ing components must be carefully calculated. As an aid to this, tables 1 and 2 show the values of R_1–R_3 and C_1–C_3 for a cut-off point of 1 kHz. Table 1 is based on standard values for the resistors and Table 2 on those for the capacitors. In practice, the latter is more convenient since the resistor values are close to the standard E-96 values.

The prototype used a Type TL081 op amp, but if high amplification factors or high cut-off frequencies are wanted, it is advisable to use an AD847.

The circuit draws a current of only a few milliamperes.

(Giesberts - 974029)



A	dB	R4	R5
1	0	....	0
1.7783	5	1k00	0.7783 x R4
2	6	1k00	1k00
3.1623	10	1k00	2.1623 x R4
5	14	1k00	4 x R4
10	20	1k00	9 x R4

Table 1. R1 = R2 = R3 = 10.0 kΩ; $f_{-3\,dB}$ = 1 kHz.

Amplification	C1 (nF)	C2 (nF)	C3 (nF)
×1 0 dB)	15.7780	22.734	4.0546
×1.7783 (5 dB)	19.1130	9.6020	7.9252
×2 (6 dB)	19.7380	8.6605	8.5084
×3.1632 (10 dB)	22.3110	6.1051	10.6780
×5 (14 dB)	25.1900	4.4843	12.8760
×10 (20 dB)	30.2550	2.8955	16.6020

Table 2. $f_{-3\,dB}$ = 1 kHz.

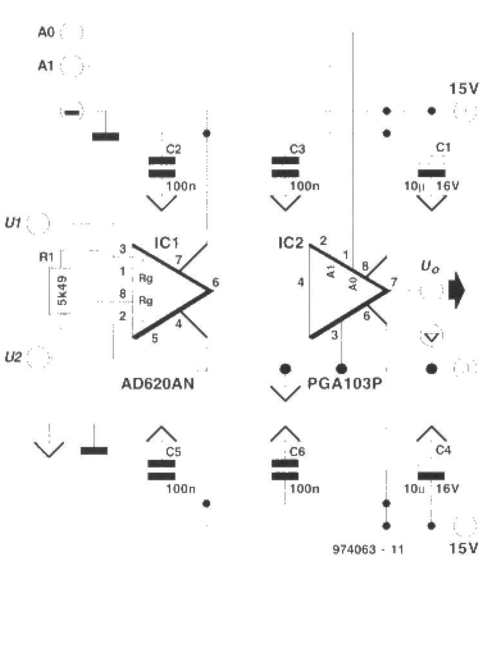
Amplification	C1 (nF)	R1 (kΩ)	C2 (nF)	R2 (kΩ)	C3 (nF)	R3
×1 0 dB)	15	10.5030	22	10.4810	3.9	10.2660
×1.7783 (5 dB)	18	10.8380	10	9.8479	8.2	9.2323
×2 (6 dB)	18	10.8860	8.2	10.8440	8.2	10.1800
×3.1632 (10 dB)	22	9.7017	5.6	11.0810	10	10.9810
×5 (14 dB)	27	10.3280	4.7	8.5890	12	10.7670
×10 (20 dB)	33	8.4821	2.7	10.7750	15	11.9070

instrumentation amplifier

The broad-band instrumentation amplifier described may be used for a number of applications. It has symmetrical inputs and a variable amplification factor.

The design is based on two op amps, of which IC_1 is the actual instrumentation amplifier. Its amplification factor is determined by R_1 and is here ×10.

Op amp IC_2 is a programmable gain amplifier whose amplification is ×1, ×10, or ×100. The amplification depends on the level at pins A_0 and A_1. When both pins are strapped to earth, the amplification is unity. When A_0 is linked to +15 V and A_1 to earth, the amplification is ×10. When A_1 is connected to +15 V and A_0 to earth, the amplification is ×100.



The overall amplification may thus be set to ×10, ×100 or ×1000.

Building the amplifier is simple and is best done on a piece of prototyping board. A good earthed link between pins 5 of IC_1 and 3 of IC_2 is pivotal.

Power requirements are ±15 V at a current of 10 mA.

The bandwidth of the amplifier is 250 kHz.

The common-mode rejection is 95 dB up to 1 kHz.

(Bonekamp - 974063)

transistor matcher

In symmetric preamplifiers and output amplifiers, it is highly advisable, if not imperative, to use truly complementary transistors. This means that the base-emitter voltage and the current amplification of the p-n-p and n-p-n transistors must be equal or very nearly so. The absolute values of these parameters are not that important.

The present circuit is intended compare these two parameters of a pair of transistors in one operation.

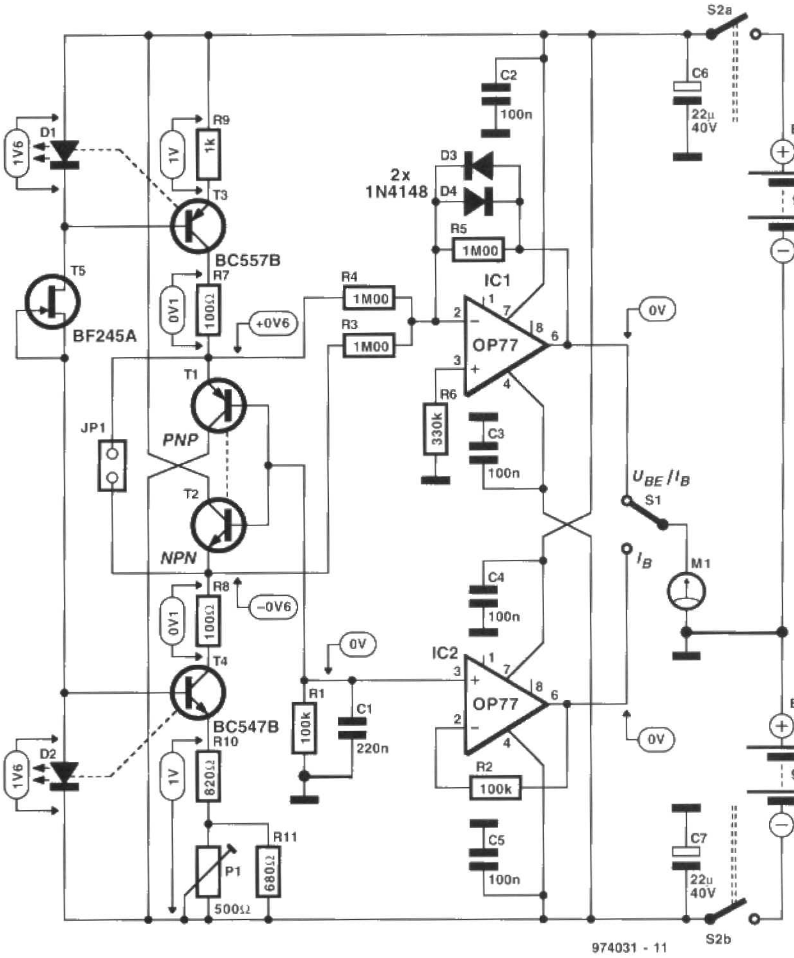
The collector current of the transistors to be paired, T_1 and T_2 respectively, is set accurately to 1 mA with the aid of current sources T_3 and T_4. Accuracy is vital and T_3 and T_4 are therefore thermally coupled to reference diodes D_1 and D_2 respectively. The current through these LEDs is held stable by current source T_5. It is imperative that the currents through T_3 and T_4 are not only stable, but also equal, and this is achieved by R_7, R_8 and P_1. The preset is adjusted so that the potential across R_7 is equal to that across R_8.

Circuit IC_1 functions as an adder. When the base-emitter voltages of T_1 and T_2 are equal, the output potential of IC_1 is equal to the base voltages of T_1 and T_2, but inverted w.r.t. them. This can be accomplished only if the amplification factors of the two transistors are equal. So, in case of a truly complementary pair, moving-coil meter M_1 will read 0 or very nearly so.

Even if a pair looks truly complementary, there is still a theoretical possibility that their base-emitter voltages are not equal, but that the difference is compensated by a difference in h_{FE}. Circuit IC_2 enables this to be verified. It buffers the voltage at the base terminals of T_1 and T_2 and these can be compared on the meter by briefly changing over switch S_1.

Any unwanted output offset may be obviated by linking the fixed terminals of a 25 kΩ preset potentiometer to pins 1 and 8 of IC_1 and its wiper to the +9 V line. Short-circuit JP_1 temporarily and adjust the preset until the meter reads 0 V. This procedure may also have to be carried out with IC_2, but in this case R_1 should be short-circuited temporarily.

Transistors T_3 and T_4 are thermally coupled to the relevant diode most conveniently if the the diodes are flat (rectangular) types. In that case, the component pairs are easily held firmly together with a cable tie.



It is advisable to use sockets for T_1 and T_2; these need not be transistor sockets: IC sockets do nicely as well. Clamp the two transistors firmly together with a clothes peg or a crocodile clip and allow them a little time to reach the same temperature. Bear in mind that temperature differences exert a great influence.

The matcher is powered by two 9 V batteries. It draws a current of about 7 mA. [Giesberts - 974031]

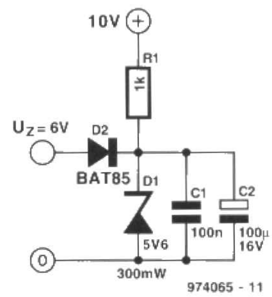
fast zener diode

Standard zener diodes are often too slow for application in signal-limiting circuits. If a fast zener is not available, the circuit in the diagram may help.

The standard zener, D_1, is linked to a direct voltage of 10 V via R_1, so that it conducts. Capacitors C_1 and C_2 buffer and decouple the zener voltage.

Diode D_2 at the junction R_1-D_1 is a fast, standard type. If the potential at the anode of this diode is higher than the zener voltage plus U_{D2}, C_1 and C_2 will compensate the inertia of the zener. So, the arrangement simulates a fast zener diode.

[Borekamp - 974065]



battery saver

The saver is intended to prevent a battery-operated instrument such as a multimeter without an automatic off switch to be left on for days on end and so completely discharge the battery.

The circuit described is inserted in the +ve supply line and breaks the +ve supply to the instrument after this has not been used for about six minutes.

Gates N_1 and N_2 form a monostable multivibrator (MMV). When the supply is switched on, capacitor C_2 arranges for the input of N_2 to be grounded, so that the output level is about equal to the supply voltage. The load is then energized.

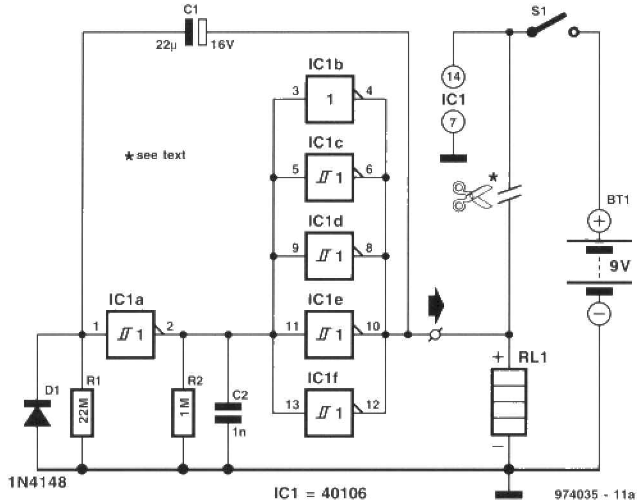
At the same time, the 9 V level at the output of N_2 is applied to the input of N_1, whereupon the output of this gate goes low. This was the initial state: nothing has changed. However, capacitor C_1 is gradually being discharged via R_1. Because of the high value of this resistor, this a very slow process. Nevertheless, after about six minutes the potential across C_1 will have dropped sufficient to cause a low level at the input of N_1. The output of this inverter changes state, so that the output of

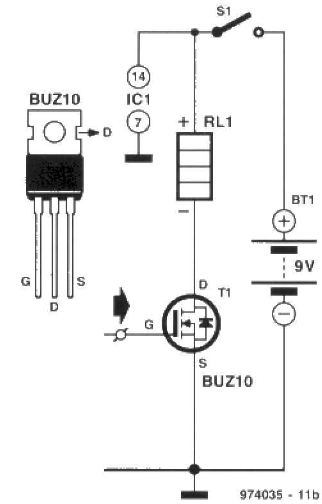
N_2 becomes low and this causes the supply to the load to be discontinued.

Restarting is effected by pressing on/off switch S_1. So as to make the current to be switched as large as possible, the remaining gates in IC_1 are linked in parallel with N_2. Each gate can provide a current of about 0.5 mA, so that the total output current is about 2.5 mA, which is quite sufficient for most test instruments. If a larger output current is needed may add a FET (BUZ10) in series with N_2: this raises the current to a couple of amperes. In that case, make sure that the −ve terminal of the load is fixed and the +ve line is switched.

If the delay of 6 minutes is found too long or too short, it may be altered by changing the value of R_1 empirically.

[Baer - 974035]

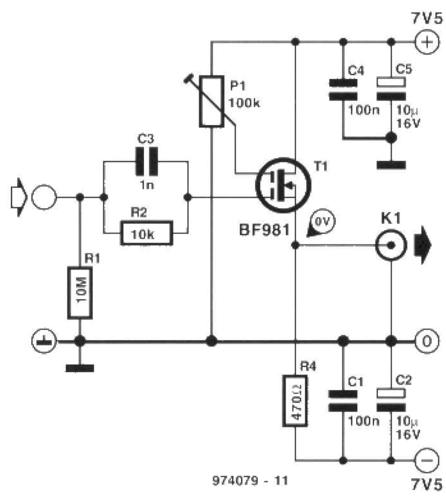




FET scope probe

Reliable measurement of an electrical quantity is possible only if the circuit in which the measurement is carried out is not loaded by the measurement instrument. The higher the input impedance of the instrument, the closer an accurate measurement is approached. The proposed probe may be used to increase the input impedance to about 10 MΩ.

A field-effect transistor (FET) is used to design a high-impedance voltage follower. In this circuit, R_1 determines the input impedance. The resistor is shunted by a parasitic capacitance of 3 pF. The output impedance depends on T_1 and R_4: with values as specified in the diagram, it is about 65 Ω.



The potential at the second gate (U_{g2s}) is set with P_1 such that the d.c. offset at the output is 0 V.

Unfortunately, a small price has to be paid for the simplicity of the circuit: since the overall amplification is ×0.8, the value measured by the oscilloscope must be corrected as appropriate.

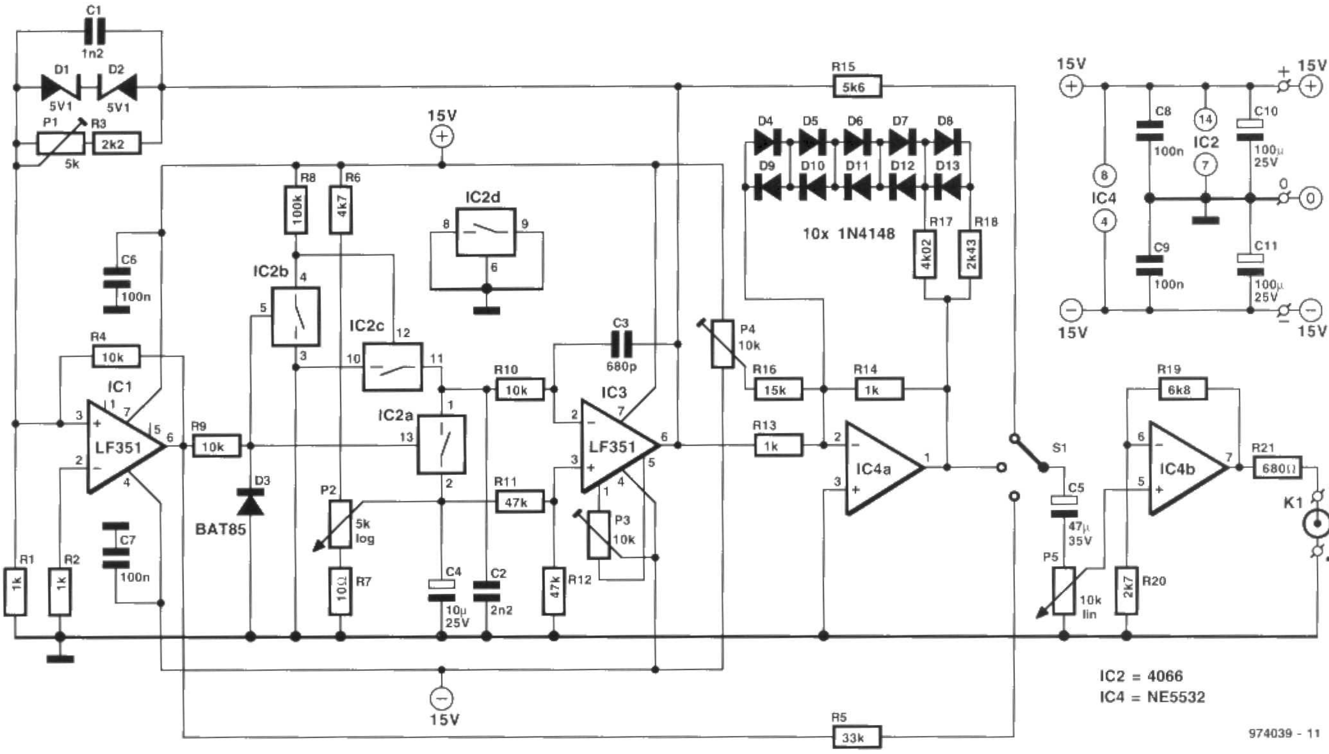
The bandwidth of the probe is ≥ 15 MHz.

The probe draws a current of about 10 mA.

[Bonekamp 974079]

single-range function generator

This function generator is traditional in as far as it consists of a comparator, an integrator and a triangle/sine wave shaper. However, a special variant of the comparator is employed to be able to cover the traditional frequency range of 20 Hz to 25 kHz in one go. At the heart of the circuit we find integrator IC3, an LF351, which uses integration network R10-C4. Unconventionally, the +input of the integrator is not connected to ground, so that the output signal is not just determined by the instantaneous level of the rectangular input voltage (and, of course, the RC network). The main function of comparator IC1 is to control electronic switch IC2a. Using this switch and IC2b, the integrator input (R10) is pulled between ground and a positive potential which is adjustable with the frequency control potentiometer, P2. This corresponds to a positive-only rectangular voltage. However, R11 and R12 also hold the +input of IC3 at half the potential on the CMOS switches. The fact that the output signal of the differentiating integrator is determined by the voltages at both opamp inputs allows a single capacitor, C4, to cover well over three frequency decades without problems. Resistors R6 and R7 determine the extreme frequencies that may be set on the generator.
Assuming that IC2b is closed, the linearly falling ramp voltage at the integrator output drops until the zener voltage of D1 or D2 is reached. When one of the zeners starts to conduct, the comparator toggles and its output swings negative. Schottky diode D3 and resistor R9 then prevent a negative voltage at the control inputs of IC2, which is only powered off the positive supply rail. IC2b then opens, IC2a is closed via inverter IC2c, and the ramp voltage at the integrator output starts to rise until the zener voltage is reached again. Next, the comparator toggles and the



COMPONENTS LIST

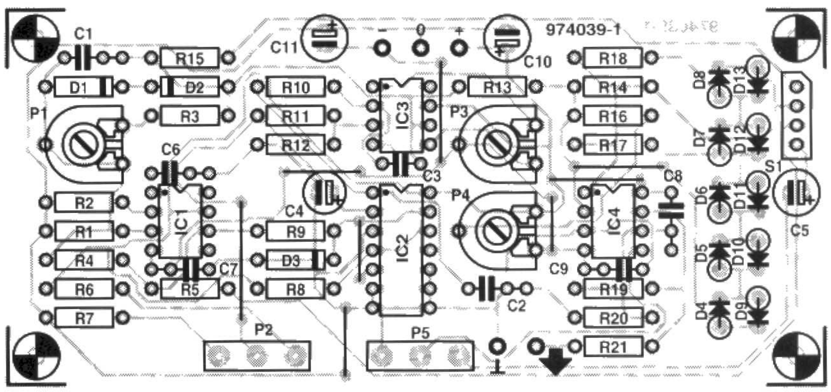
Resistors:
R1,R2,R13,R14 = 1kΩ
R3 = 2kΩ2
R4,R9,R10 = 10kΩ
R5 = 33kΩ
R6 = 4kΩ7
R7 = 10Ω
R8 = 100kΩ
R11,R12 = 47kΩ
R15 = 5kΩ6
R16 = 15kΩ
R17 = 4kΩ02
R18 = 2kΩ43
R19 = 6kΩ8
R20 = 2kΩ7
R21 = 680Ω

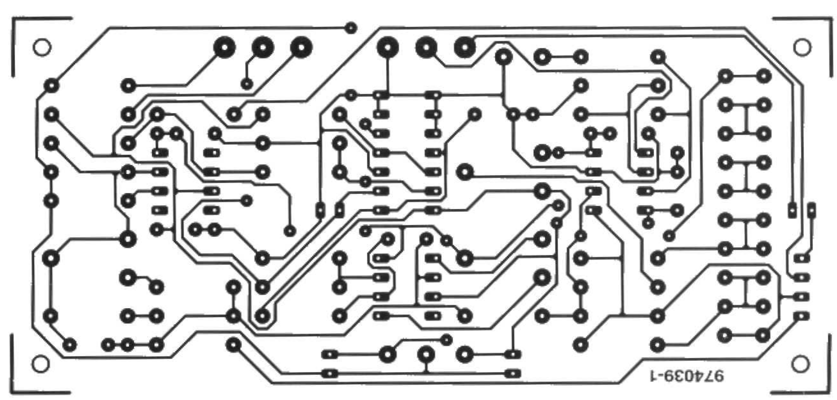
P1 = 5kΩ preset H
P2 = 5kΩ logarithmic potentiometer
P3,P4 = 10kΩ preset H
P5 = 10kΩ linear potentiometer

Capacitors:
C1 = 1nF2 (see text)
C2 = 2nF2
C3 = 680pF
C4 = 10µF 25V radial
C5 = 47µF 35V radial
C6-C9 = 100nF
C10,C11 = 100µF 25V radial

Semiconductors:
D1,D2 = 5V1 400mW
D3 = BAT85
D4-D13 = 1N4148 (matched pairs)
IC1,IC3 = LF351
IC2 = 4066
IC4 = NE5532

Miscellaneous:
K1 = BNC socket
S1 = rotary switch, 1 pole, 3 positions





oscillation cycle starts again, creating a triangular and a rectangular signal at the output of IC3 and IC1 respectively. Because the triangle-to-sinewave converter requires a virtually constant drive signal, the reference level created with the zener diodes can be tweaked with preset P1. Capacitor C1 eliminates a small rise of the triangle signal at higher frequencies, depending on component tolerances and construction.

The triangle-to-sinewave converter uses an NE5532 opamp and matched diode pairs. Details on its operation may be found in the April 1995 issue of *Elektor Electronics*.

The values of resistors R5 and R15 ensure roughly equal peak-to-peak values of the generator output voltage at all three positions of waveform selector switch S1. The generator output impedance is about 600 Ω, the maximum (no-load) output voltage, about 20 V_{pp}.

The generator is powered by a symmetrical, regulated, 15-volt supply. The General Purpose Power Supply described in the April 1997 issue is perfect for the job if you use the 7815/7915 voltage regulator pair. Current consumption is about 22 mA on each voltage rail.

The only critical parts in the circuit are the high-frequency compensation capacitor, C1, and the fre-

quency control pot, P2. The optimum value of C1 may have to be established empirically, while a good-quality logarithmic potentiometer has to be used for P2. If at all possible, go for a real gear and dial assembly, because the full frequency range is compressed into a span of 270 degrees. As regards the level control, P5, a logarithmic pot may be preferred over a linear one if you want to be able to set small output levels accurately.

The generator is adjusted with the aid of a dual-beam oscilloscope and presets P1, P3 and P4 on the board. Initially, set P2 and P5 to mid-travel, and connect one scope channel to the output of IC3. Next, turn down the frequency with P2, and carefully adjust P3 for optimum symmetry of the triangular wave. Move the probe to the output of IC4a, and set the generator to a frequency of about 1 kHz. Adjust P1 and P4 for the best possible sinewave shape. For these adjustments, it is convenient to have the other scope channel display the triangular signal (at the same sensitivity), and move the trace onto the sinewave. In this way, any asymmetry of the sinewave is easily detected and eliminated.

Monitor the output of IC3 again, this time for stability of the output level across the full frequency range. If necessary change the exact (equivalent) value of C1 until the level is virtually constant.

Finally, check the upper and lower frequency extremes, which should be a little over 25 kHz and a little under 20 Hz respectively. If necessary, modify R6 and/or R7.

The printed circuit board shown here is unfortunately not available ready-made through the Readers Services.

(974039 - F. Hueber)

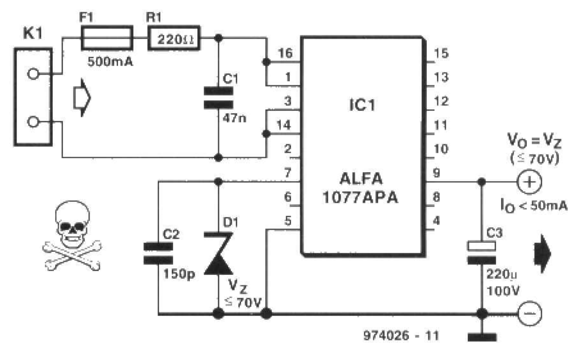
single-chip ac-dc inverter

The Type α10777APA IC is an integrated ac-dc inverter that can handle inputs from 18 V r.m.s. to 276 V r.m.s. It contains a switch-mode amplifier and a rectifier bridge. It is able to provide a very compact, light and inexpensive power supply with a minimum of external components. The peak output current is 50 mA. The output voltage may be set at voltages up to +70 V with the aid of zener diode D_1.

The inversion process depends on charging and discharging a capacitor during each ac input cycle. At the start of the cycle capacitor C_3 is linked to the internally rectified direct voltage via a switch and is then charged to +70 V (equivalent to the internal zener voltage) or to the zener voltage of D_1. After the positive half-cycle the switch opens, whereupon C_3 is discharged via the load during the subsequent negative half-cycle. The process then repeats itself, so that C_3 is charged during each positive half-cycle. Charging does not start, however, until the input voltage is about 1 V higher than the potential across C_3.

The IC can handle input frequencies between 48 Hz and 200 Hz. The switching rate and thus the charge-discharge frequency is always twice the input frequency.

Note that the circuit is electrically connected with the mains supply, so that the supply as well as the circuit being supplied must be housed in a non-metallic enclosure.



[An Alpha Microelectronics Application - 974026]

AC-DC converter

The circuit in the diagram converts a sinusoidal alternating voltage into a direct voltage equal to the r.m.s. value of the input voltage. What makes the circuit special is that this conversion, that is, rectification, averaging and buffering, is effected by only two op amps. The usual circuits for this kind of conversion are generally much more complex.

Op amp IC_{1a} provides half-wave rectification of the applied alternating voltage. The values of R_1 and R_3 give unity amplification.

Op amp IC_{1b} amplifies the output of IC_{1a} ×2 and adds this to its input via R_2. This results in a potential that is equal to the absolute value of the input voltage. This potential is amplified ×2.22, that is, the form factor times 2 (that is $2\pi/2\sqrt{2}$), at a delay time R_5-C_1 (= 2.22 s).

Op amp IC_{1b} also functions as a buffer for the whole circuit.

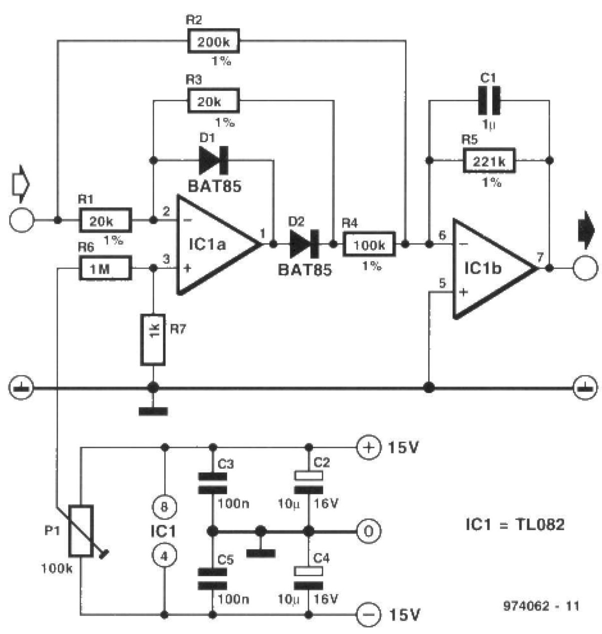
Since the operation of this type of converter depends on the absence of any offset voltage, this is nullified by network R_6-R_7-P_1. Setting is simple: apply a 1 kHz sinusoidal signal at a level of 50 mV r.m.s. to the input of the converter and adjust P_1 until the output is a direct voltage of 50 mV.

The input voltage may vary from 50 mV to 7 V.

The input frequency may vary from 10 Hz to 10 kHz.

Accuracy of conversion is better than 2%.

The circuit draws a current of about 3 mA.



[Borekamp 974062]

AF input selection

Input selection in the battery operated preamplifier published in the January 1997 issue of this magazine is by rotary switch. This does not give the best possible performance as far as crosstalk and channel separation are concerned. This article proposes a better means, which also enables the number of input to be extended to 12. In this design, each input source is linked to the circuit via a bistable relay (described elsewhere in this issue).

Use is made of a single-pole, 12 position rotary switch, S_1, with which and 12 pull-down resistors the input source is selected. Since only one resistor is linked to the positive supply line at any one time, the current drawn by the circuit is only 15 μA, which, in the case of a battery operated preamplifier, is an important advantage.

The 12 outputs of S_1 are linked to parity checker IC_3. The output of this device is high only if an odd number of inputs is high. When S_1 is turned, all inputs go low briefly and so the output of S_3 also becomes low for an instant. The output of IC_3 then triggers monostable multivibrator (MMV) IC_{4a}. Since this is retriggerable, its output will be a single pulse even with contact bounce of S_1. As long as trigger pulses arrive during the period the output is active, the output pulse is stretched. To make absolutely sure, the time can be set with P_1 between 0.1 s and 1 s.

The outputs of S_1 are also linked to D-type bistables IC_1 and IC_2, which ensure a stable change-over of the output levels. The bistables have the advantage that they can be reset. This facility is made use of by resetting all relays before a change of input, so ensuring that only one input is linked to the circuit at any one time. This arrangement provides a dead time between the releasing of one relay and the tripping of another. This dead time corresponds to the sum of the mono times of IC_{4a} and IC_{4b}. MMV IC_{4b} serves to clock the inputs of all the D-type bistable. Since this requires a pulse of only 10 μs, the dead time is determined primarily by IC_{4a}.

The $\overline{Q}$ output of IC_{4a} is used to reset the D-type bistables, but it also provides the reset pulse for all relays together. Accordingly, the new data from S_1 is accepted by the D-type bistables 10 μs after the reset pulse. To enable the position of S_1 to be assumed during the rise time of the supply lines, the bistables need an additional pulse and this is provided by R_5-C_3.

About 4 seconds after the supply has been switched on, the 13th input of the parity checker changes state, which results in the output of IC_3 changing from low to high and the triggering of IC_{4a}. This means that all relays are reset after switch-on, immediately followed by the enabling of the relevant input. This entire process must be completed before the output of the preamplifier becomes active.

The circuit requires a power supply of about 15 V. The diagram shows how this may be derived from the $\pm$7.2 V supply of the battery operated preamplifier.

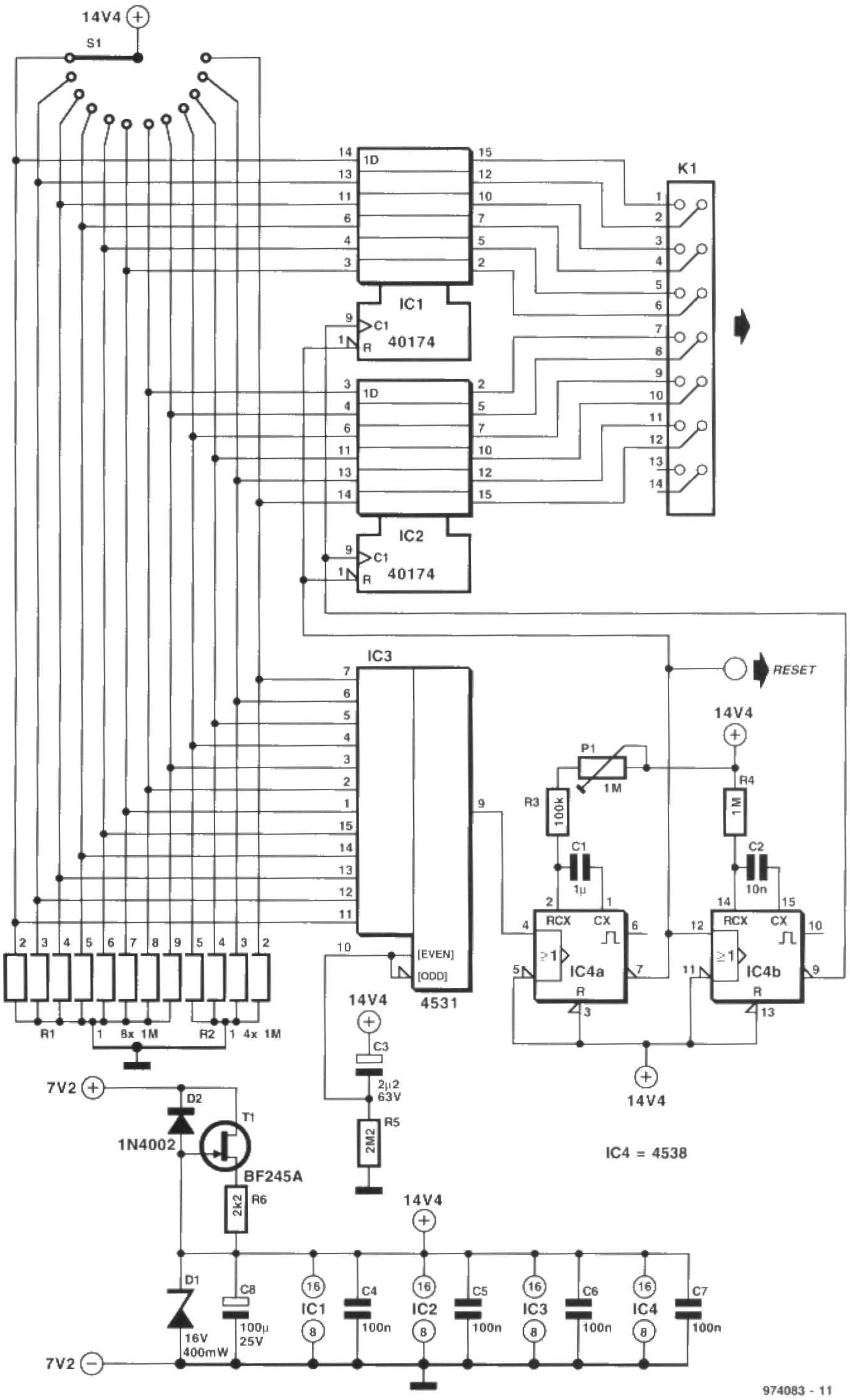
The ICs are protected against overvoltage by zener diode D_1. To ensure that the current through this diode is held within limits when the battery voltage is high, current source T_1 is provided in series with D_1.

When the supply voltage is lower than 15 V, the drop across R_6 and T_1 may be ignored, but when it is higher, the current is limited to about 400 μA.

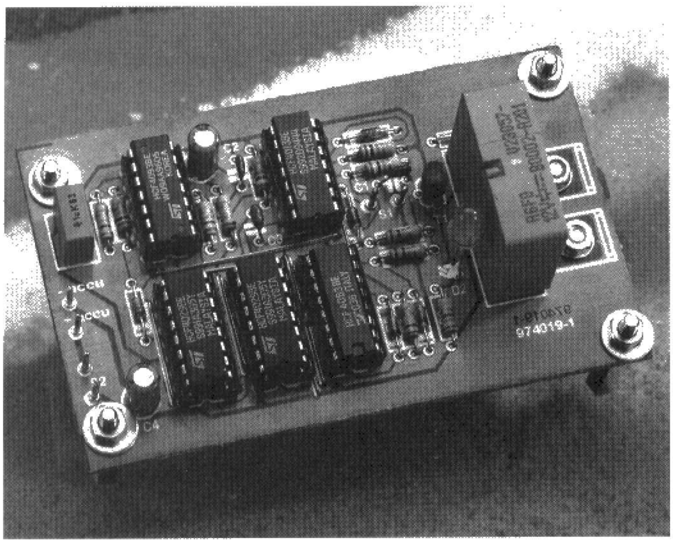
The value of capacitor C_8 is purposely large since this component provides the energy required for changing over the inputs. This becomes clearer on reading the 'AF input module' elsewhere in this issue.

Finally, diode D_2 prevents C_8 being discharged via T_1.

[Giesberts - 974083]



adaptive windscreen wiper control

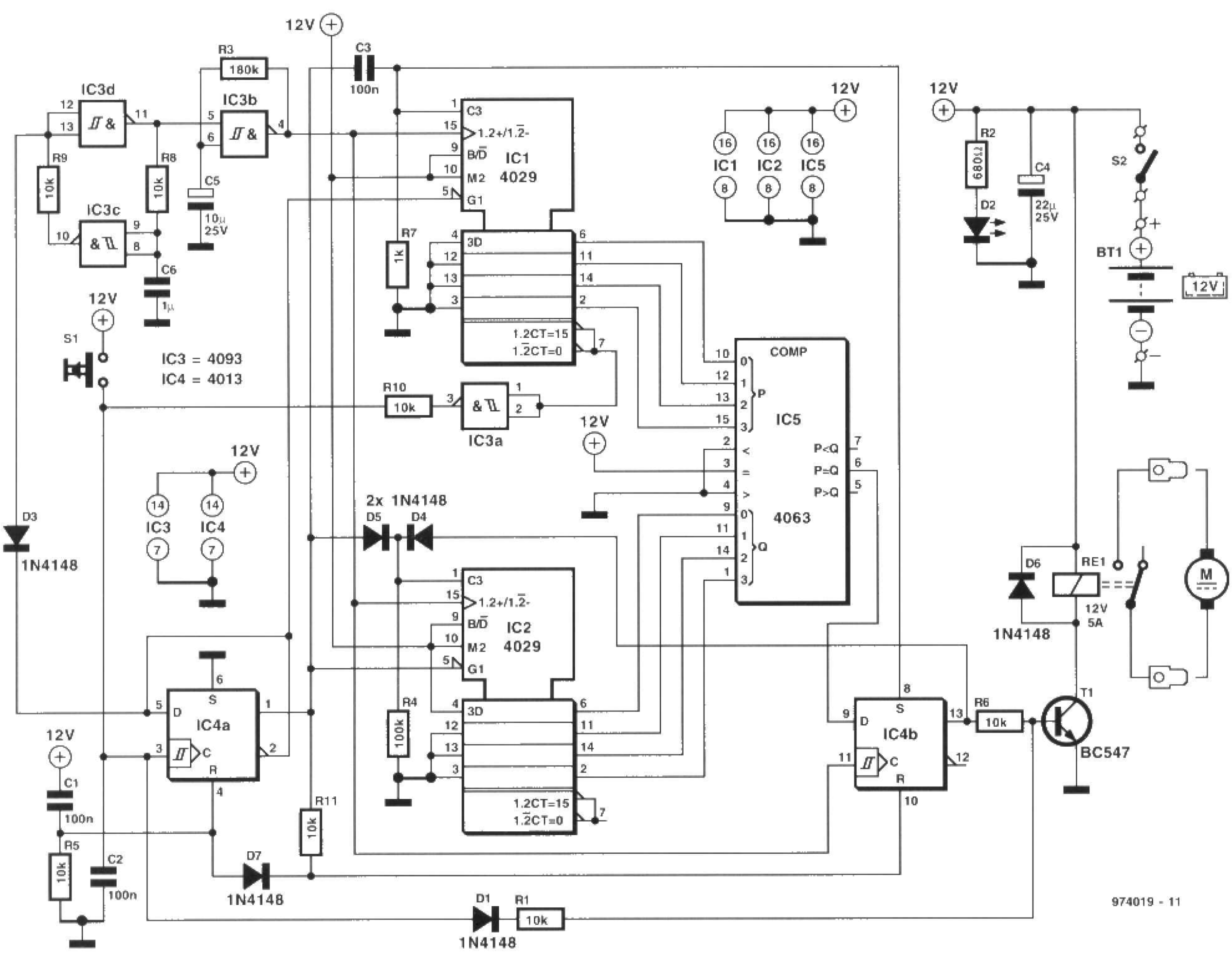


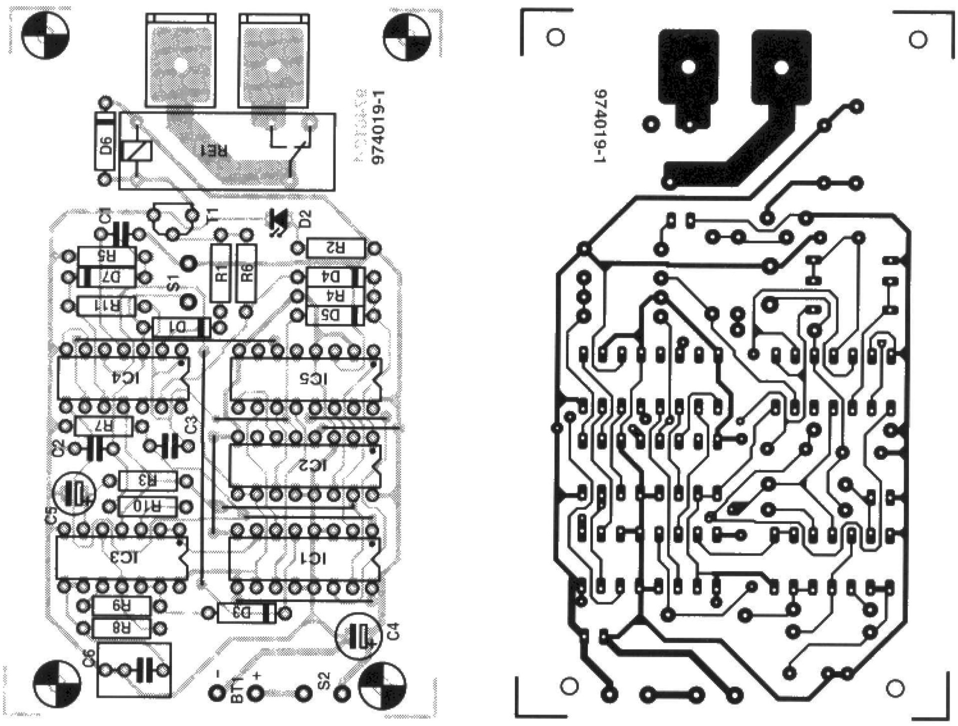
Although a very useful car accessory, the typical adjustable windscreen wiper interval control never seems to get it right; the delay between wiper activity is either too short or too long, and you seem to be forever busy tweaking the interval control pot to match the amount of rainfall. A more or less automatic adjustment to rainfall variation has an intuitive touch: measure the time between two wiper actions performed by the driver, store this delay, and then use it to control the wipers automatically. This approach is also used in some of the latest Volkswagen (VW) models.

The circuit shown here is based on common-or-garden CMOS logic wired to form a clock/counter configuration. The unit is controlled by a single push-button, S1, and an on/off switch, S2. The push-button acts as a start/stop control which determines the length of the wiper interval. Regrettably, it will not be possible in many cases to employ the wiper control lever already fitted on the steering column, and a suitable location will have to be found for the push-button on the dashboard. If you are lucky, however, the existing wiper control simply switches the 12-V supply to the wiper motor relay. In that case, the switched voltage may be taken to the 'lower side' of S1 (see circuit diagram), and *hey presto* the circuit will work without the external push-button.

At the heart of the circuit are two 4094 counters, IC1 and IC2. The first counter sets the (variable) wiper delay, while the second operates in free-running mode. Both counters receive a 1-second clock signal from Schmitt trigger oscillator IC3b, which is not enabled until the bistable around IC3d and IC3c is in the set state. Because of 4-bit comparator IC5, the wiper relay, Re1, will only be actuated if the state (output value) of IC2 equals that of IC1.

The interval delay is the time elapsing between two actions on push-button S1. On the first action, IC1 starts to count, and continues counting until either S1 is pressed again, or IC1 produces a carry-out pulse via inverter IC3a. This happens when the counter has cycled through all its possible states (16). Consequently, the Q output of IC4a drops low, causing IC2 to start counting, and IC1 to hold. D7 and R11 prevent the wiper relay from being actuated during the interval adjustment period, because IC1 and IC2 then briefly produce the same





output value, 1, which equals the preset value loaded by IC2.

When the counters produce equal output states, the data input of D-bistable IC4b goes high. At the next clock pulse, the Q output will change to high, causing IC2 to be preset with the value 1 again, and the relay driver, T1, to be switched on. This again clears the '1' at the input of IC4b, causing the PE (preset enable) signal to disappear and IC2 to start counting again.

The wiper motor(s) may be controlled directly by Re1, or indirectly using the existing relay fitted in the car. In the latter case, Re1 may be a much lighter type than indicated in the components list.

Regrettably, the printed circuit board shown here is not available ready-made through our Readers Services.

(974019 - H. Bekkema)

COMPONENTS LIST

Resistors:
R1,R5,R6,R8-R11 = 10 kΩ
R2 = 680Ω
R3 = 180kΩ
R4 = 100kΩ
R7 = 1kΩ

Capacitors:
C1,C2,C3 = 100nF
C4 = 22µF 25V radial
C5 = 10µF 25V radial
C6 = 1µF, pitch 5mm or 7.5mm

Semiconductors:
D1,D3-D7 = 1N4148
D2 = red LED
T1 = BC547
IC1,IC2 = 4029
IC3 = 4093
IC5 = 4063

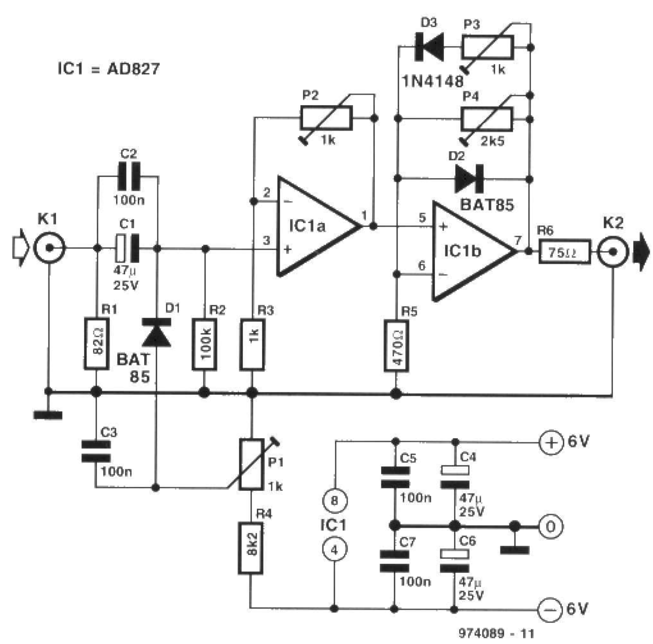
Miscellaneous:
Re1 = relay, 12VDC coil, 250VAC/8A contact, e.g. Siemens V23057-B2-A201
Two spade terminals for car electrical connectors
S1 = push-button, 1 make contact
S2 = on/off switch

video-contrast expander

It may happen that a video recording is a little too dark so that certain nuances disappear and the picture is no longer clear. The expander may rectify this to some extent by increasing the contrast in the dark passages. Provided that the circuit is set up correctly, the nominal black and white levels are not affected.

The circuit has four calibration points, which make the use of an oscilloscope a must. It is, of course, important that the existing black and white levels are retained and that the synchronization remains fully functional.

The circuit has a few drawbacks: (a) owing to the added amplification, the level of the colour burst changes, which requires the saturation to be readjusted; (b) the contrast in bright images diminishes; and (c) there is a risk that when the dark levels are amplified too much noise becomes visible.



The input signal at K_1 is decoupled by C_1, C_2 and R_2 and then amplified by IC_{1a}. Diode D_1, in conjunction with R_4 and P_1, ensures that the earth level is used as reference for the black level. The output level is set with P_2.

Diode D_3 in series with P_3 in the feedback loop of IC_{1b} holds the white level at 100%. This ensures that small signal levels (dark levels) are amplified in accordance with the setting of P_4, while larger signals are also affected by the setting of P_3.

Diode D_2 limits the level of the sync signals which, owing to the chosen amplification, may become too high.

Experimenters may replace D_3 by one or two Type BAT85 diodes or a simple germanium diode, which, of course, changes the operating characteristic of the circuit.

Note that the signal input must give a level of 1 V_{pp} across 75 Ω - no more, no less. Remember that 30% of the available space must be reserved for the sync signals.

The circuit draws a current of ±15 mA.

(Giesberts – 974089)

state-of-charge tester

The tester is intended to determine the state of charge of a NiCd or NiMH battery precisely. Also, the counter module linked to it it enables the capacity to be read. It is meant for a battery containing 12 cells, which makes it suitable for use with the battery-operated preamplifier published in the January/February issues of this magazine.

When the start knob is pressed, the battery on test is discharged at a predetermined current of, say, 50 mA. At the same time, a pulse generator is enabled which produces a number of pulses per hour corresponding to the discharge current in mA (i.e., 50). When the battery has been discharged to about 75% of its nominal e.m.f., discharging is terminated and the pulse generator is disabled. The number of pulses generated during the discharge period is shown on the display of the counter.

The current source instrumental in the discharging of the battery is based on IC_{1a} and T_1. The op amp corrects the drive to T_1 until the potential across R_1 corresponds with the reference voltage set with P_1. The reference is provided by zener diode D_1 the current through which is held constant by T_3. The values specified in the diagram refer to a discharge current of 125 mA. The values given in brackets refer to a discharge current of 50 mA. Which is to be used depends on the capacity of the battery: generally, a discharge current of 1/10 of the capacity of the battery gives best results.

To determine whether the battery is discharged, its terminal voltage is compared with a second reference potential derived from the supply lines for the digital part of the circuit via R_{10}-R_{11}-P_1. Comparator IC_{1b} changes state when the battery voltage drops below 11.25 V (set with P_2). Thereupon T_2 comes on, so that the wiper of P_1 is linked to earth and the current source is disabled. The hysteresis provided by R_8-R_9-D_1 prevents the comparator changing state again when the battery voltage rises slightly owing to the ceasing of the discharge current. Pressing S_1 resets the comparator to its original state.

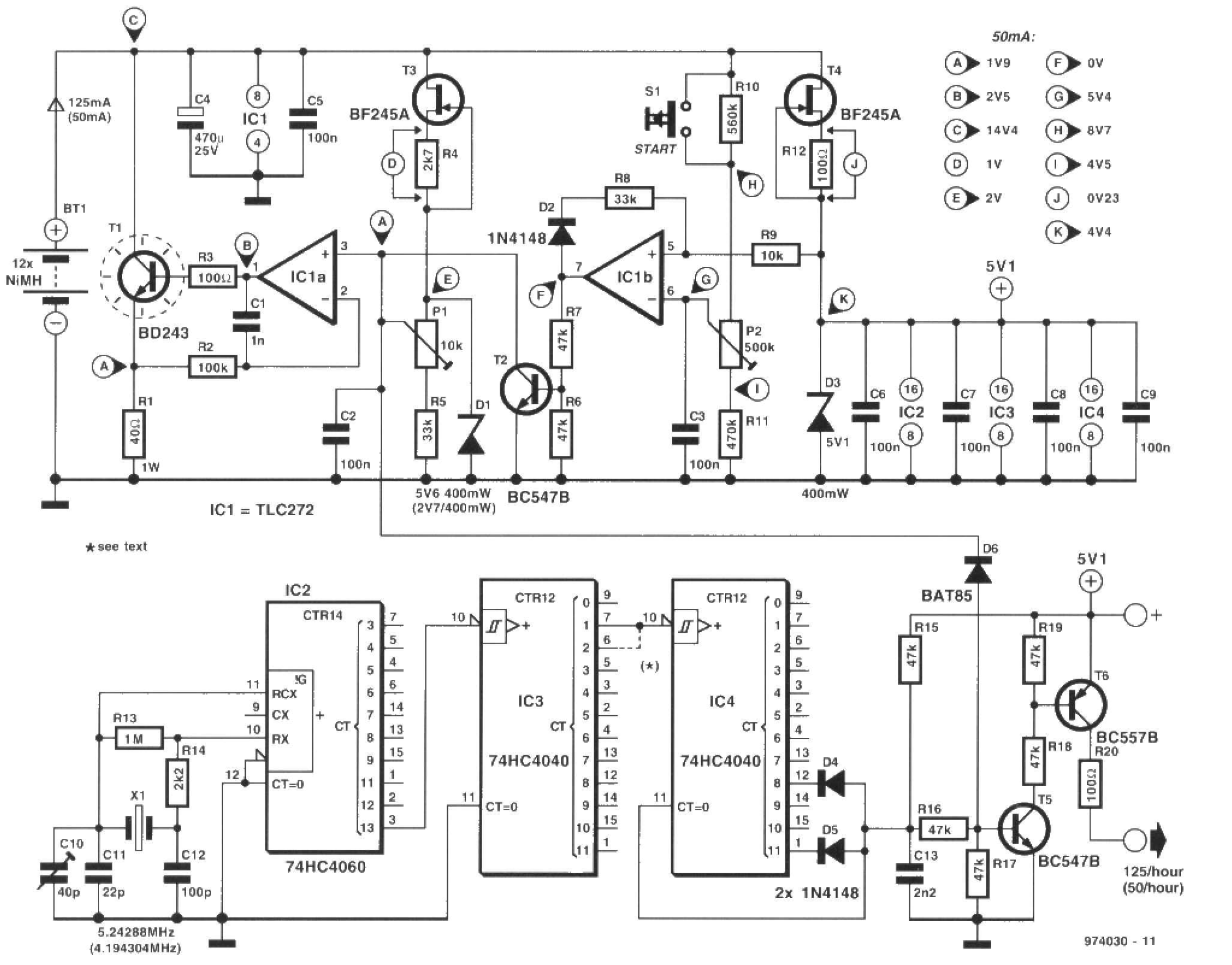
The digital section of the circuit consists of pulse generator IC_2-IC_3-IC_4-T_5-T_6 and a ready-made counter module (e.g. Voltcraft Type 195650). The generator provides 50 or 125 pulses per hour, depending on the level of the discharge current. In the first case, the oscillator in IC_2 runs at 4.194304 MHz, which is brought down to 0.0139 Hz (or 50 pulses per hour) by a three-stage divider. When the discharge current is 125 mA, the divisor of IC_3 is changed from 2^3 to 2^2, and the crystal frequency to 5.24288 MHz. These two alterations result in a raising of the pulse rate by a factor 2.5 (= 125).

The counter module at the output is powered by an AA battery. Counting is commenced when the counter module is short-circuited briefly ($\leq 100\ \mu s$) to the positive supply line. Capacitor C_{13} ensures that the short-circuit pulses are of the correct width, while T_5 and T_6 arrange correct matching between the output of the divider chain and the input of the counter module.

The +ve terminal of the counter module is linked to the +5.1 V supply to the pulse generator, so that T_6 comes on for every output pulse, whereupon the counter increases by 1. When the battery is fully discharged, so that T_2 begins to conduct, the output of the pulse generator is blocked because T_5 is disabled via D_6.

If a different type of counter module than the one specified is used, it may be necessary to alter output stage T_5-T_6 slightly. To what extent changes are necessary will be clear from the data of the module.

(Giesberts 974030)



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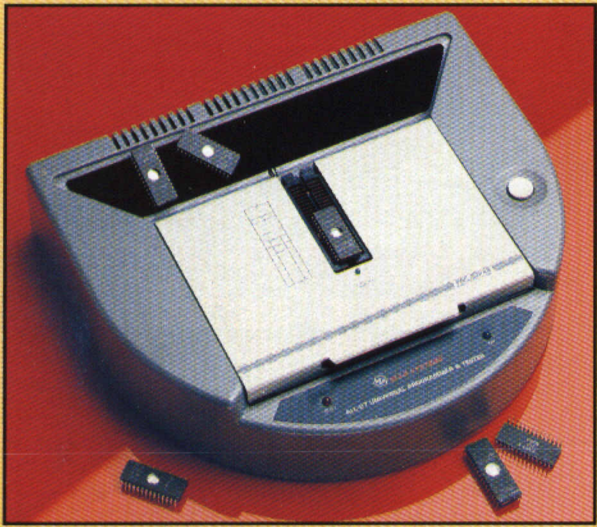

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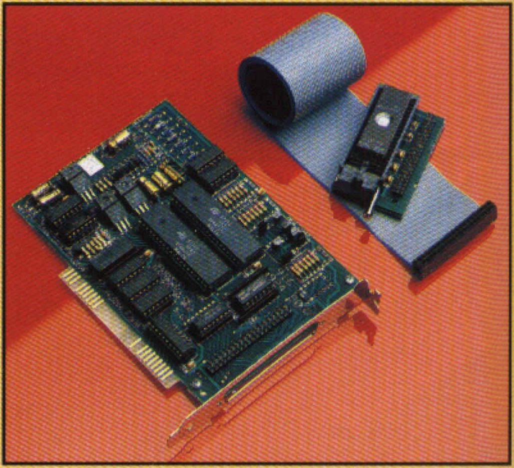

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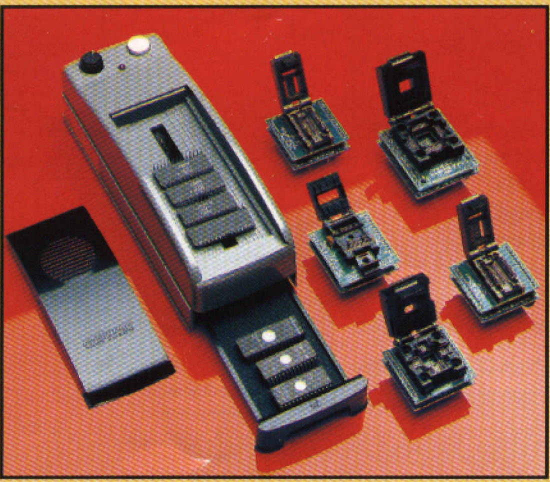

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